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A MONOGRAPH

OF THE

BRITISH EOCENE FLORA.

BY

JOHN STARKIE GARDNER, F.L.S., G.S., M.G.S. France, &c.

VOL. II.

GYMNOSPERMÆ.

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LONDON:
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INTRODUCTION.

The study of Tertiary fossil floras appears hitherto to have had so few attractions that not one of the many competent British botanists has expressed a wish to undertake it. The material is fragmentary, and important organs are wanting, and they therefore consider the conclusions based upon them to be unsatisfactory. I would willingly have allowed, for my part, that my labour should have consisted in collecting specimens and accumulating facts for the use of men with more special knowledge, but on account of their silence, and lest the material should perish, I here venture to describe the British Eocene Coniferæ.

Such considerations have not weighed to the same extent abroad, and so large a number of works have been published on fossil plants that it seems strange that scientific speculation should have been so little influenced by them. The most ordinary inductions that these investigations might have given rise to have been overlooked, though they would often have facilitated the determination of the plants themselves.

The Marquis de Saporta, whose work takes the widest grasp, has almost alone seized the obvious inference that a flora within the Arctic circle must, in a period of decreasing temperature, have preceded the same flora in the latitude of Italy; and if the theory so ably argued by him, that a large proportion of the Miocene flora actually originated in the north, requires modification through more recent discoveries, it has at least served its purpose in rendering new departures possible. Any endeavour to connect the facts before us one with another, and render them intelligible, must add to their importance and enable geologists to follow with increased interest a study hitherto given over to specialists.

Our Eocene floras, from below the London Clay, for example, seem exceedingly homogeneous and present relatively few species. They are, as long since pointed out by Sir J. Hooker, in the case of fossil plants from Reading, of remarkably temperate aspect, the leaves and fruits of the Plane tree being conspicuous, among a number of undetermined prevailing types. This flora has sufficient leaves and fruit identical with

the Greenland plants in Mr. Whymper's collection, and which rarely occur in any other Tertiary floras, to show a close relationship. One inference from this is obviously that when the warmer Eocene period set in during the formation of the London Clay the older and more temperate Eocene flora was driven far north, where it probably remained until a gradual diminution of heat enabled it to come south again. The effect of the convergence on the land-areas of the Pole for so long a time of, perhaps, very dissimilar floras from different longitudes, consequent on this rise of temperature in the northern hemisphere in Eocene time, might naturally lead to a mingling to some extent of the floras of the three northern continents, so that they might have redescended enriched with a quantity of new forms. During all this lapse of time they were probably becoming modified in the direction of existing trees, and in that sense no doubt species did originate near the Pole as Saporta claims. When they reoccupied the temperate latitudes of Europe they constituted the Miocene flora. The discovery, which I have abundantly confirmed, of an Eocene temperate flora in the south of England—and consequently of a period when arctic conditions were probably not greatly dissimilar to those of the present—fully explains the break in the sequence between Cretaceous and Tertiary floras noticed all round the Arctic Circle; and is a considerable step towards a comprehension of the past, and even existing, plant distribution of the northern hemisphere, and one therefore whose ultimate bearings can as yet only be shadowed forth. The migrations, comparatively simple with regard to temperate floras, are infinitely complicated when those of the sub-tropics, which replaced them in Europe, are considered. The causes which led to the association together of types now characteristic of widely separated latitudes and longitudes in one area during the Middle Eocene must have been very varied, and seem, as yet, not to admit of any entirely satisfactory explanation.

These types, it is evident, are now to a great extent represented in areas as widely separated as tropical America, North-East Australia, and the East coast of Asia and adjacent isles. The plants from Mull and Antrim, described by some as Miocene, might, like those nearer the Pole, belong to any age between the beginning and the end of the warmer Eocene period; but they cannot be of earlier, and are unlikely to be of later date. Whether, and to what extent, the Cretaceous floras of Greenland and Dakota are connected with the older temperate Eocene floras, and what relationship the Aix-la-Chapelle flora bears to them and to still older Cretaceous floras, is as yet quite unknown and presents problems of deep interest.[1]

[1] Towards the practical solution of such questions I have, during twelve years, collected plants from the British Eocenes. The results, although considerable, might have been greater had I found it possible to utilise assistance to any extent, but my experience has been that collections of fossil plants lose the greater part of their value when not directly made by those actually engaged in their study. I have further procured, where possible, collections from deposits of other countries, such as Sézanne, Gélinden, Céreste, and the Paris Basin, places whose Tertiary floras seemed likely to assimilate to those of Britain. Many collections of Tertiary plants have of late years come into the possession of the British Museum, and will, I hope, shortly be available for comparison.

When our British Eocene floras are compared with those of other countries we can hardly fail to observe that no Eocene or Oligocene fossils are described as occurring within upwards of two thousand miles of the Pole. All the fossil floras containing Dycotyledons within that radius have been in fact described as either Cretaceous or Miocene.

The correctness of this classification, which has been maintained and extended by Heer even in his latest works, is open to doubt, for there is no evidence in those regions of any break in the physical conditions which could have rendered unlikely the deposition of materials similarly adapted to the preservation of plant remains. Further, the supposed Miocene either rests directly upon, or is separated by not more than one thousand feet from the deposits described as Cretaceous. From the unquestioning way in which this classification has been generally received, we should expect to find it based upon well-nigh irresistible evidence. Instead of this, the Miocene hypothesis supposes that at least 25 per cent. of the forest trees and shrubs ranged at that period from Spitzbergen to Switzerland, and from Disco to Italy; a distribution without parallel at the present day. On the other hand, the temperature of the Eocene period would have been far more favorable to the growth of temperate floras in high latitudes; for the minimum estimated temperatures of our Middle Eocene and of the so-called Greenland Miocene differ by only 20° Fahr., or as nearly as possible one degree for each degree of latitude. At the present day the distance from England to Madeira produces an almost identical variation of temperature and a practically similar change in the flora. Setting aside, however, all other considerations, I believe I shall be able during the progress of this work to show that the evidence of the fossil plants themselves, relied upon by Heer, does not support the anomalies introduced by his classification, but, on the contrary, favours the view that deposition of sediment in which plants have been preserved did not cease in high latitudes during the Eocene period.

It is obvious, in such an inquiry, that floras from the south of England, supposed to be of the same age, are too widely separated in latitude from those of Greenland to permit of any useful comparison being made directly between their species. It would be almost tantamount to a person, totally unacquainted with the flora of the intervening American mainland, comparing the leaves of the forest trees of Cuba with those of Nova Scotia, in the hope of identifying them together. Their mutual relationship must chiefly be traced, and the problems contingent upon it solved, either through the older temperate Eocene floras, of which they may be supposed in part descendants, or through the deposits containing dicotyledonous plants preserved in intervening lands. Instances of the former are found at Reading, Newhaven, Bromley, &c., and of the latter in some of the western isles of Scotland, in Antrim County in Ireland, at several localities in Iceland, and possibly also in some of the many deposits of lignite in the Faroe Isles.

The specimens already obtained from Mull, though not very numerous, contain some striking forms of the English sub-tropical Middle Eocene, such as *Podocarpus*, mixed with

others common to Greenland. The newly-discovered deposit at Canna appears to have yielded only two species, both of which are also found at Mull. The Irish beds are generally admitted to be of the same age as those of Scotland, and have many species in common. They are especially interesting; for, while containing several species characteristic of our Middle and Lower Eocene, they also contain, like some of the Lower Eocene beds in France, Greenland species not yet recognised at Mull. As connecting links all these are therefore of the highest importance.

It is scarcely less important to obtain collections of plant remains from a series of beds of well-defined ages from as nearly the same latitude and longitude as possible, for a scale of temperatures, ranging from at least the Lower Eocene to the Pliocene, could be compiled from them. In England we have a probably unrivalled series of Eocene plants, whose relative ages, with the exception of those from Bovey-Tracy, are established on the most unequivocal palæontological and stratigraphical evidence. For the Lower Eocene group these are the floras from Newhaven, Reading, Dulwich, Bromley, Croydon, Lewisham, &c.; for the London Clay group, Sheppey, Herne Bay, Alum Bay, and Studland; for the Middle Eocene, Bournemouth and Bovey-Tracy; and for the Upper Eocene and Oligocene, Hordwell, Gurnett Bay, and Hempstead. From most of these localities collections may still be made, and some of them are remarkably prolific. Bournemouth has yielded a far larger number of distinct species of a Tertiary flora than any other locality; and I have received during the past two years nearly 20,000 fruits from Sheppey and Herne Bay.

In France the series of plant-bearing beds is even more complete. It commences, it is believed, at a lower stage, that called the "Paleocene" by Schimper, and extends upwards to the Upper Pliocene. The following list of localities from which floras have been obtained has been supplied by the Marquis de Saporta, who has at all times rendered me willing assistance. The Paleocene plants may to some extent, however, be equivalent to the Lower Eocenes of England. They are represented in the Paris Basin by the tuffs of Sézanne and the Grès de Belleu or Grès du Soissonnais, in Belgium by the Gélinden limestone, and by the concretionary limestone of St. Gély (Hérault) in the South. The Calcaire-grossier stage is represented in the Paris Basin at the Trocadéro and by the Grès de Brives, and the Grès de Marne-et-Loire and of the Sarthe. It is, however, in Languedoc and Provence that the floras become of greatest interest, for there the sequence is uninterrupted from the Eocene, through the Tongrian or Oligocene, to the Mayencian stage of Heer. The exact sequence is:

Upper Eocene: Zone of Palæotherium.—Gypsum of Aix.
Lower Oligocene.—Gypsum of Garges.
Middle Oligocene.—*Calcaire marneux* of St. Zacharie.
Middle Oligocene.—*Calcaire marneux littoraux* of the Marseilles Basin.
Upper Oligocene.—Bonnieux and Céreste near Apt.

Newer Oligocene (*Oligocène récent*) or passage-beds to Aquitanian.—Armissan near Narbonne, and Brognon, Côte-d'Or.

Lower Aquitanian.—Lignites of Manosque (Basses Alpes).

Upper Aquitanian.—Clays of the Marseilles Basin and Schists of Gergovie.

Lower Miocene.—Ménat in the Auvergne.

Upper Miocene.—Mont Charray.

Newer Miocene (*Miocène récent*).—Flora of Théziers.

Lower Pliocene.—*Cinérite du Cantal,* basaltic tufas of Auvergne, and tufas of Meximieux.

Middle Pliocene.—*Tufs de la Valentine* near Roquevaire (Bouches du Rhône), and *Marnes de Ceyssac*, Haute Loire.

Upper Pliocene.—*Marnes de Durfort* (Gard).

Twenty-three localities from which floras have been obtained are enumerated in this list. Those between the Gypsum of Aix and the Lower Miocene of the Auvergne form a practically homogeneous series in one locality, and are, therefore, of great value in tracing the gradual decrease in temperature, and the consequent departure or modification of the Tertiary plants of Europe.

Our British series is thus supplemented in France by both older and newer floras; and is repeated from the Middle Eocene upwards, but in a still more complete form, and seven degrees further to the South.

In America the conditions seem to be even more favorable, since a vast series of floras, ranging in age from Cretaceous to Pliocene, is known to exist in the Western Territories of the United States. If these can be connected, by the work of Principal Dawson, with those of the Arctic Circle, and if these floras and our own are ever studied with the same care that the Marquis de Saporta has bestowed on those of France, the results must be of most extreme value. A scale could then in time be constructed by which the ages of fossil floras of even remote countries might be determined, but which must otherwise remain doubtful. Such determinations are at present liable to error, as there are no recognised and fixed types from any latitude which are universally acknowledged to be characteristic of either the Cretaceous, Eocene, or Miocene systems.

In the first place, in determining the relative ages of fossil floras, the probability that temperature differed in somewhat the same degree as at present, in different latitudes and longitudes, seems seldom sufficiently considered, and an almost universally equable temperature in the Eocene and Miocene times has been assumed, without evidence that such was the case. The similarity between such widely separated fossil floras as those of Iceland and Italy renders it very improbable that they could be of the same age, especially if the causes which led to the increased warmth during the Eocene in high latitudes were purely terrestrial. Again, the probable nature of the station

in which the plants grew is rarely taken into account. It appears, for instance, that the floras of our Middle Eocene enjoyed an exceptionally favorable climate, moist and in close proximity to a very warm sea. Those of Aix, though so much farther south, had a dry and less favorable station, and therefore contrast with ours in point of luxuriance, for there moisture-loving plants seem to have been excluded until a later period. Other stations, such as Bovey-Tracey, eighty miles from Bournemouth, situated among hills which probably helped to furnish the materials of the Bournemouth deposits, may have stood considerably above the sea-level, and would present in consequence a slightly more temperate flora, which has been interpreted to be younger. In comparing American plants it should be remembered that the climate of the United States, even during the Eocene, was, latitude for latitude, cooler than that of Europe. Other examples might be instanced, but sufficient is stated to show that so far from it being possible to define the relative ages of fossil floras by their mere comparison, this class of palæontological evidence requires perhaps exceptionally philosophic treatment. A knowledge of the probable conditions under which Tertiary plants lived is an essential preliminary to their study, and a few considerations under this head will be of use.

The curves of the lines indicating the limits of trees towards the Pole, as well as of the isotherms, show very strikingly the cooling effects of descending Arctic currents upon the surrounding land. Wherever Arctic water penetrates in gulfs or bays, or finds egress, the limit of trees is deflected ten degrees south; while currents flowing northward carry the lines with them by fending ice off the shore. We need not seek farther than Iceland for an illustration of the changes in climate that a temporary diversion of an Arctic current will produce. In 1757 Greenland ice remained on the north shores of Iceland, and produced throughout the summer a cold equal to that of the depth of winter, which did not diminish under a mid-day sun, the air remained misty and snow fell frequently throughout May and part of June, preventing the growth of grass. The previous year snow fell to a depth of two feet on the 26th June, and continued to fall frequently during July and August with excessive cold. The ice left on the 26th August, and the snow then melted. A similar visitation in 1753 had destroyed nearly the whole of the cattle, and the ponies ate wood, peat, and flesh.

It seems from this example, and from the difference between the isotherms of Europe and America in the same latitudes, that ice-laden currents are of themselves capable of lowering temperatures by twenty or thirty degrees. It is a question whether the exclusion of ice altogether from the North Atlantic might not be sufficient to raise its temperature generally by some 20° Fahr. It is admitted that continuous land did exist during the Eocene period between Europe and America, in about latitude 70°, and this land must have completely excluded floating ice from seas to the South of it. If this cause were admitted to be capable of producing so great an effect, no other explanation of the presence of the floras that are met with in Greenland and in England would be required. The sudden rise seen in the temperature of the London-Clay period, both in

Europe and America, as well as the commencement of the warm Tertiary period in Greenland, might have been brought about by the completion of this land connection. Further, the universal gap in the Arctic plant series between the Upper Cretaceous of the Atane and the Eocene (the so-called Miocene) would also be explicable, since the plant-beds below the London Clay are filled with Plane and forms resembling Hazel and Lime, which represent a climate so nearly approximating to that of these latitudes at the present day that no forest of leafy trees could possibly have co-existed with them in the Arctic Circle.

There have been many attempts to restore the contour of Europe during Eocene and Miocene times. The principal difference appears in its central and southern parts, which were then to a large extent occupied by an extension of the Mediterranean Sea. India appears also to have been an island, and the chief mountain-ranges were hardly upraised. England was united to what then existed of France above water, and the two formed an isthmus which probably stretched towards Denmark and Scandinavia, and served to separate the waters of a then existing North Sea from a sea which extended south to the Mediterranean and Southern Atlantic. The present Eocene Basins of Hampshire and London seem to have formed part of one vast river-delta, which originally extended over portions of France as well; but, while the whole of our Eocenes are delta deposits, the plant-beds of Europe are almost exclusively lacustrine or tufaceous. Judged from the area and thickness of its deposits, the river which flowed from the west must have drained a land of continental dimensions, and it may well be that the then relatively small area of Europe, Asia, and a part of North Africa, was compensated by a vast stretch of land to the West, upon which the immensely varied Eocene forests, whose remains are to be described, must have succeeded each other. By some means or other there migrated to this continent, as the temperature increased, at first a flora whose predominating types seem to be Australian, and then a flora whose characteristics are essentially Neo-tropical. The latter, at least, were accompanied by a corresponding group of pulmonate Mollusca, a type of which, the gigantic *Bulimus* of the West Indies, swarms with its eggs in the Bembridge Limestone of the Isle of Wight. The Australian flora died out, or migrated South again, while the Neo-tropical flora passed across Europe, and seems to have reached finally the East Coast of Asia, where some of the Eocene species still appear to exist. The submarine ridges that have been mapped seem to furnish an explanation of the route that these migrations may have taken, and shadow precisely the connections which the plants independently prove to have existed; indeed it is difficult to imagine what the banks which traverse the ocean may signify if not either rising or sinking land. From beginning to end of the Tertiary Period the Western Continent, which, notwithstanding the prejudice that this name provokes, may as well be styled *Atlantis*, was diminishing while Europe was extending its area. Briefly sketched, these appear to have been the conditions under which the Eocene plant-world, to be described in these pages, existed. The

difference between deposition in flowing and in still water has, it will be seen, greatly influenced the relative characteristics of the floras.

Unfortunately authors when describing fossil plants have seldom given indications of the reasons which have led them to adopt one genus in preference to others with similar fruit or foliage; and they do not state why they have unhesitatingly attached generic and specific names to the most ordinary forms of leaf, whose bases or tops are wanting. If, for example, the suspicion communicated to me by a very distinguished botanist is well founded, that the oldest known dicotyledonous leaf is not *Populus*, and that the leaves determined as *Vitis*, from near the Arctic Circle, are not vines, all the theories built on their presence are valueless. The practice of identifying plants from different localities, by comparing them with lithographs, also very often leads to false assumptions; for, apart from inaccuracies introduced by artists and engravers, the finer variations, and, above all, the texture, are seldom represented; and single leaves especially can seldom be definitely identified without a comparison between actual specimens.

Although there are these difficulties, very valuable knowledge may be derived from the study, when the indefinite is omitted, and the same methods are used as in other branches of palæontology. It is fortunate that there are some fossil plants among those of the Tertiary Period which require no special ability to identify; others, however, require very careful consideration; and there are a few about which, in the present state of our knowledge, it would be unsafe to say anything, though it may be useful to record their existence. The relative value of these determinations should be made quite apparent and the indeterminable forms omitted entirely from all speculations.

I now pass on to a review of the groups of vegetable forms revealed in the British Eocene deposits.

GYMNOSPERMÆ.

Although the Gymnospermæ are classed with Dicotyledons and with Exogens in many Botanical Classifications, and are therefore placed in a higher scale than Monocotyledons, no apology is needed in a palæontological treatise for introducing them next to the lowest class, the Cryptogams. Lindley, in 1833, recognising their somewhat anomalous characters, grouped the Cycadeæ, Coniferæ, and Taxineæ into a primary division, called by him Gymnospermæ, equal in value to the Exogens and Endogens, and placed next the Acrogens or higher Cryptogams. They have since been variously placed; but, whatever value may be attached to them in classifications as a primary division, they are now recognised to include the Cycadaceæ, the Coniferæ, and the Gnetaceæ.

The Gymnosperms so far exceed in antiquity either the true Dicotyledons or the Monocotyledons, that it has long been felt that through them, if at all, the evolution of Phanerogams from Cryptogams would be traced. Notwithstanding, however, that the external resemblance of Cycads to Palms, and the similarity of certain Coniferæ to Ferns and Club-mosses, had led to much speculation as to their derivation, no satisfactory connection could be traced; and although they have been often claimed boldly as the connecting link between the highest and the lowest classes of plants, all the evidence, when sifted, has hitherto proved at best negative; and the early appearance in geological time of so highly specialised a type of plant has consequently been made use of by the opponents of evolution. Darwin, indeed, contrasted the direct fertilisation of the naked ovule by the pollen, with the admirably ingenious contrivances by which many other plants are fertilised by insect agency. "Can we consider," he says, "as equally perfect, the elaboration by our fir-trees of dense clouds of pollen, in order that a few granules may be wafted by a chance breeze on to the ovules?" Lindley also considered them analogous to reptiles in the animal kingdom; but it seems to be reserved to Saporta and Marion to bring to light the actual stages through which the evolution of the Gymnosperms has taken place; and as we have been led in their 'Evolution of Cryptogams' from the primeval Cellular Thallogen, step by step, through Vascular Cryptogams up to the Gymnosperm, so may we hope that their forthcoming volume will trace, as satisfactorily as they feel confident it will, the stages through which the

Phanerogam has become in its turn developed from the Gymnosperm.[1] To the present, however, the remains of former forests which have been found scattered, with wide intervals, through stratified rocks, have scarcely rendered it possible to trace the lines through which the evolution of any of the existing groups of plants has taken place. Still the known antiquity of completely differentiated Acrogens and Gymnosperms is such that we can only suppose the common ancestors of the spore-producing Lycopod and seed-producing Gymnosperm to be locked up in the form of graphite and other carbons in the estimated 70,000 feet of sedimentary strata comprised between the Laurentian and Devonian formations. Yet in a general way the development of the vegetable kingdom may be divided, as long since pointed out by Adolphe Brongniart, into three great periods—that of the Acrogens, of the Gymnosperms, and of the Angiosperms. In the oldest sedimentary rocks there are, as is well known, few recognisable plant remains; but in the Silurians, impressions ascribed to Cryptogams, and wood of a very anomalous and primitive character, are occasionally met with. In some of the Devonian rocks wood with the typical coniferous structure abruptly appears; but in other localities of the same age wood has been found with a structure tending to show that the Coniferæ were less completely differentiated. Angiosperms appear much later.

In 1831 Witham pointed out that the higher and more complex organisation of Coniferæ existed in the Carboniferous strata of Edinburgh and Newcastle. This was at one time believed to possess an Araucarian structure, and more recently to be nearer the Pines; but there is a complete absence of true cones in the Carboniferous; and the fruits, such as *Trigonocarpus* and *Nœggerathia*, have been thought by Hooker and Saporta to be allied to Ginkgo. If the frequent reference of the earliest known Conifers to such types as Araucaria and Ginkgo should be confirmed by future discoveries, it would be a matter of considerable interest to find that the forms, which at the present day still closely approach in their foliage the Club-mosses and Ferns, are the older types. Ginkgo presents in its mode of seeding, according to Saporta and Marion, a nearer approach to Cryptogams than to any existing Phanerogam.

From the base of the Permian the Gymnosperms are more defined. Voltzia,

[1] The publication of that important work 'L'Evolution des Phanérogames' has been delayed owing to the desire of its authors to vindicate the determinations of Algæ in 'L'Evolution des Cryptogames,' and a comprehensive memoir on "Les Algues Fossiles" has appeared. In the meantime the Marquis de Saporta has favoured me with a note (29th November, 1882), in which he informs me that the parts treating of the *Progymnosperms*, *Gymnosperms*, and *Metagymnosperms* or *Gnetaceæ* are completed: "Nous nous basons pour tracer le mouvement évolutif des Phanérogames sur l'étude analytique de la structure des tiges ou plan caulinaire et aussi sur celle des parties intimes et essentielles de l'ovule, de manière à faire voir comment le passage organique a pu s'opérer sans effort et graduellement des types cryptogamiques de l'ordre le plus élevé vers les Phanérogames proprement dites. Il y a là une série de nuances dues au déplacement ou à la distribution relatives des diverses zones de tissus composant la tige, et aussi une série de modifications conduisant de la macrospore à l'ovule et du prothalle inclus vers le sac embryonnaire et les corpuscles, qui permettent de saisir le sens et la direction du mouvement evolutif d'où sont à la fin sorties les vraies Phanérogames, d'abord uniquement gymnospermiques."

formerly supposed to possess near affinities with Araucaria and Cunninghamia, has been thought by Saporta to belong to the Taxodieæ, the very distinct types of foliage included in the genus perhaps accounting for the divergent views. The widely-spread Walchia and Ullmannia have been generally supposed to be Araucarian, although the latter has also been placed in the Cupressineæ. The Cycadaceæ were largely developed throughout the Permian and until the close of the Jurassic period.

In the Trias, besides some doubtful Cupressineæ, two prevailing types occur—a form of Voltzia, thought by Schimper to be related to the existing Cryptomeria, and Albertia, related to Dammara. Coniferous structure is abundant in the Lias, both the Araucarian and Pine structures having been partially recognised, and we meet with the names Widdringtonites and Thuyites. Four species of the latter are known from the Stonesfield slate besides Araucaria; and Solenhofen has been stated to have yielded Pinus, Araucaria, and Arthrotaxites. The Secondary Period has in fact been described as the age of Gymnosperms; and during the Jurassic especially they formed almost the entire forest vegetation. Schimper enumerates more than sixty species of Cycadaceæ; the Cupressineæ and Taxodineæ are undoubtedly represented; and what appear to be cones of true Araucaria and Pinus have been met with in several localities at home and abroad. *Ginkgo digitata* is indistinguishable from the existing Ginkgo, and the *Pachyphyllum* from the middle estuarine series of Yorkshire bears a striking resemblance in its foliage to *Araucaria Cunninghami*, but possesses very much smaller and persistent cones.

The Wealden Flora scarcely differs from that of the Jurassic. The scanty British Cretaceous Flora, described by Carruthers, is almost entirely Coniferous; Cedrus having been met with in the Lower Greensand at Maidstone, Shanklin, and Folkestone; Pinus and Amber in the Gault, and Sequoia in the Gault and the Blackdown Beds. The Cretaceous Flora of Hainault is also entirely Coniferous, and is described by Coemans as containing links between the existing groups of Abies and Cedrus, Strobus and Pinaster, Cembra and Strobus. Germany is said to have yielded cones of Dammara and Araucaria from the Cretaceous. Cedar cones have also been found in the Wealden of the Ardennes; and Cedar and Pine cones occur in the Lower Cretaceous of Havre. Most of these cones have, however, been described from unique or almost unique specimens, and from external characters only. The Cretaceous Flora of Aix-la-Chapelle, in which both coniferous fruit and foliage are abundant, warns us that very unexpected internal characters may be combined, even in the later Cretaceous rocks, in a cone which appears outwardly to be of an existing genus. Thus a cone bearing every outward resemblance to Sequoia possesses under each scale a number of Cupressineous-like seeds, while the foliage approaches that of Libocedrus. The Columbea, or broad-leaved, and the Eutassa, or needle-leaved, types of Araucarian foliage, are both met with in great abundance at Aix-la-Chapelle and also in French localities; their constant association together suggesting that they may belong to a single dimorphic species. Several very anomalous Coniferæ, such as Inolepis and Cyparissideum, are met with in the Lower-Cretaceous Komeschichten

of Greenland, and elsewhere, in beds of the same age; the whole tending, perhaps, to show that the existing genera of Coniferæ were less completely differentiated previous to the Eocene time than has been generally supposed. For the Arctic Kome Heer claims Pinus and Tsuga, and Pinus and Abies for Atane; the leaves of *Pinus Credneri* are described as lying in thousands on some of the slabs; so that, even in Cretaceous times, forests of needle-leaved Coniferæ must have characterised northern latitudes. Pinus and Sequoia are also described from the North-American Cretaceous of Dakota.

In the Tertiaries the Gymnosperms are quite subordinate to the higher Phanerogams, yet in 1878 Lesquereux estimated that no fewer than 225 species were known from them.

Of the three orders of Gymnosperms two are recognizable in British Tertiary rocks, the Cycads being absent, and the Gnetaceæ only met with in the London Clay of Sheppey. Of the six orders of Coniferæ all seem more or less certainly represented.

Among the Cupressineæ, there is Libocedrus foliage from Bromley and from the London Clay perfect examples of fruits, apart from the doubtful species of Bowerbank, belonging to a section of Callitris met with in Australia; though only that now confined to Africa occurs in Ettingshausen's list of Sheppey fruits. But there is no ground for including Callitris or Cupressinites in the Alum-Bay flora. In the Tertiary swamp-clay of Bournemouth there are in places innumerable detached twigs, which precisely resemble those of *Sequoia Couttsiæ* at Bovey; but the few cones associated with them are distinctly Cupressineous. Types of Libocedrus and Thuya appear in the South of France in the Oligocene, and the North-African Callitris is found in the Eocene of Aix. A number of other Cupressineæ have been described from fragments scarcely deserving notice. Of the Taxodieæ we appear to have representatives of Sequoia, Taxodium, and perhaps Athrotaxis; but those in the Alum-Bay list are probably Podocarps of a single species. The *Sequoia Bowerbankii* of the Sheppey list by Ettingshausen, found only at Herne Bay, and in which four species of Bowerbank's Petrophiloides had been absorbed by Heer, is a cone of the Alder, and bears no resemblance to Sequoia. *S. Langsdorfii* may occur at Mull and Antrim, but the foliage only is known. *S. Couttsiæ* from Bovey is one of the oldest Eocene forms; and, unlike other species characteristic of the European Tertiaries, was not dimorphic. The Arctic species confounded with *S. Couttsiæ* is also found at Antrim. It is quite distinct, and might be fittingly named after Mr. Whymper, who brought many specimens from Greenland. *S. Sternbergi* is, as originally described, an Araucaria allied to *A. Cunninghami*, but a distinct species of Sequoia has since been confused with it. The Arctic Cretaceous Sequoiæ were evidently polymorphous, and are divided into quite an unnecessary number of genera; as it is palpable in some cases that more care or good fortune in collecting would have shown that two or three supposed species grew on one branchlet. We have strong evidence of Taxodium and its sub-genus Glyptostrobus in England, foliage from Bournemouth belonging probably to the former as well as the latter. Both are represented in the Oligocenes and Miocenes of Europe and of Greenland, and are valuable indications of

temperature. Cones are of necessity associated with the fruits in most of the forms known definitely to belong to the Taxodieæ.

Of the Taxeæ, Ginkgo or Salisburia occurs in Ettingshausen's list of Sheppey plants; but it is just possible that the resemblance in the form of the seeds is accidental, for they appear to have a hilum, and are of much smaller size. Forms of Ginkgo are associated with nearly all the northern floras, from the Jurassic age onward, but seem absent in temperate Europe between the Jurassic and later Miocenes. The Podocarpeæ, again, are much more numerous than they appear in Ettingshausen's lists. At Bournemouth there are at least two types, one of which, with long articulated leaflets, extends north to Mull and Antrim, and is common in the Middle Eocene of Europe. There are Podocarp berries at Sheppey; and all the remains of Conifers from Alum Bay are now placed in a single species of Podocarp with dimorphic foliage.

Of the Araucarieæ, Araucaria is certainly represented in our Eocene, and is confined to the upper part of the Bournemouth series. The former connection of this with the Australian region, indicated by this Conifer, is strengthened by Callitris and Podocarpus; while the remainder of the Coniferæ confirm the close connection with America and Eastern Asia, already rendered apparent by the Ferns. The Abietineæ have taught but little hitherto; but cones of Pinus have been found near Canterbury, at Herne Bay, the Isle of Sheppey, Bracklesham, Barton, Gurnet Bay, and Antrim. Ettingshausen believed that bodies resembling scales of cones from Alum Bay, and a pair of indistinct acicular impressions from Bournemouth, indicate the presence of Pinus in these floras. Strong evidence that all the freshwater deposits, whence floras are obtained in England, were deposited in running water is afforded by the fact that they are so devoid of remains of Pines; since it is certain, from their common occurrence in the marine formations, that they formed part of our flora throughout the whole Tertiary Period.

Sir Joseph Hooker has recently expressed the opinion that "Of all the orders of fossil plants of the formations referred to (the Cretaceous and Tertiary strata of North America), the Gymnosperms alone have, as a rule, yielded much trustworthy information; and this is due to their texture, to the peculiar character of their vegetative and reproductive organs, to the frequent adhesions of these to the branchlets, to their gregarious habits, to their wide distribution, and to their close affinity with existing species." But the study is, on the other hand, rendered difficult by the great similarity existing between the foliage of widely separated genera, and the rarity with which fruits are found associated with it, at least in deposits formed in flowing rivers. The relative persistence of the various fruits to the branchlets, the piecemeal manner in which so many cones are shed, and the greater length of time they float compared to the foliage, are points seldom taken into account. Just as we might infer when pinnæ of Ferns are found abundantly without any trace of sori that the fertile fronds were separate, so when cones are never mingled with foliage we might suppose that they were shed either piecemeal, or at a different time of year, or else possessed very different powers of flotation.

Order—CYCADACEÆ.

These are palm-like Gymnosperms with usually unbranched stems, often marked with lozenge-shaped leaf-scars, and bearing parallel-veined, hard, pinnate leaves. The wood is soft and pith-like, with the characteristic gymnospermous structure. The seeds are hard and woody, and borne on the edges of modified leaves, or in large cones, which are either sessile or pedunculate. They are generally low shrubs, but occasionally reach a height of thirty feet. They possess the general aspect of Palms combined with the fruit of the Coniferæ. There are two tribes, CYCADEÆ and ENCEPHALARTEÆ, with nine genera, and from 75 to 100 species, inhabiting intertropical or subtropical America, Asia, Australia, and the Cape.

For many years Cycads were believed to occur in the Carboniferous, but later investigation has not confirmed these views. They abounded in England during the Jurassics; and excellent illustrations of them are to be seen in Buckland's 'Bridgewater Treatise,' the 'Transactions of the Geological Society,' 2nd ser., vol. iv, and in Lindley and Hutton's 'Fossil Flora.' Carruthers has also published a monograph "on the Fossil Cycadean Stems from the Secondary Rocks of Britain," in which all the species are redescribed and figured.[1] They have also been met with in the Jurassic of Spitzbergen, and in great quantities in the Cretaceous Komeschichten of Greenland. They seem to become rare in the Newer Cretaceous of Atane, and disappear altogether in the Arctic Tertiaries. They migrated apparently from temperate Europe and America during the Tertiary Periods, and the few supposed remains of them found hitherto in the Tertiaries are in an unsatisfactory state of preservation.[2] None are known in our Eocenes.

Order—CONIFERÆ.

The Coniferæ form by far the most extensive of the Gymnospermous orders. As at present constituted, it consists of hard-wooded trees or shrubs, of exogenous growth, and with polycotyledonous embryos; but their woody structure is marked by discs, a peculiarity which renders it easily recognisable in almost every state of preservation. Their spiral vessels also are limited to the medullary sheath. They are both dicœcious and moncœcious; the female flower being either in cones or solitary, and the male flowers usually in deciduous catkins, composed of a number of scales, in the body

[1] 'Trans. Linn. Soc.', vol. xxvi, p. 675, 1870, (read June 18th, 1868). This appears by far the most important contribution to the history of Fossil Cycads, and is illustrated by ten very beautifully drawn plates. M. Renault, 'Cours de Botanique Fossile, Première année,' Paris, G. Masson, 1881, devotes the first six chapters to fossil Cycadaceæ.

[2] These are—a small fragment from the Miocene of Switzerland, named *Zamites tertiarius*, Heer; two fragments from Gélinden, named *Z. palæocenicus*, Saporta and Marion; a cycadaceous leaf and indistinct cone from Bonnieux, and the *Encephalartus* from Koumi, in Eubœa.

of which the pollen is contained (figs. 1 and 2). The name is derived from the cone or strobilus on which the great proportion of them produce their seeds (fig. 3). This is a fruit-spike, more or less elongated, and covered with scales or bracts, formed of metamorphosed leaves or branchlets; each scale has usually two seeds at its base, which are enveloped in a hard coriaceous integument, and often winged (fig. 4). The scales are sometimes united, as in the Cypress, and form a rounded mass, or become fleshy, as in the Juniper, where they unite to form a globular fruit or berry. In the Taxeæ and

FIG. 1.—Male or Anther-bearing Catkin of Spruce Fir. Natural size.[1]

FIG. 2.—Female or Ovule-bearing Catkin of Spruce Fir. Natural size.

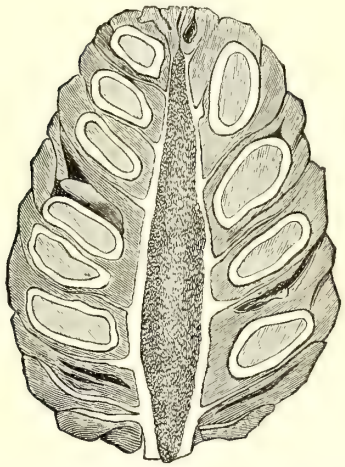

FIG. 3.—Longitudinal section of a cone of the Stone Pine (*Pinus pinea*), showing the relative position of the axis, scales, and seed. Two-thirds natural size.

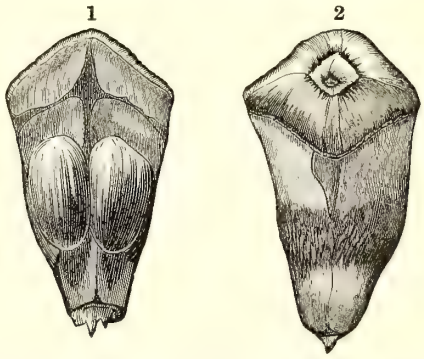

FIG. 4.—Scale of *Pinus pinea*, natural size. 1. Inner side with seeds. 2. Outer side, showing the swollen terminal portion called the *apophysis*, with its central protuberance.

Podocarpeæ the fruit is solitary and terminal, the external succulent covering being formed of modified bracts surrounding a naked seed. They are mostly trees or shrubs, with branched, resinous trunks, and abound in the temperate regions of both hemispheres.

Although they no longer play the chief part in forest vegetation, the Coniferæ still form a conspicuous feature in the physical geography of the earth. The needle-leaved Pines, Firs, Cedars, and Larches form enormous forests in the Northern Hemisphere;

[1] Figures 1 to 4 are from Veitch's 'Manual of the Coniferæ.'

and Araucarias, Podocarps, Dammaras, and Dacryds occupy corresponding tracts in the South. No genus inhabits the plains of the Tropics; they belong essentially to the Temperate and Subarctic Zones. In northern regions the members of this group outnumber the broad-leaved trees by ten to one; and even on the Pacific slopes of America extensive tracts are densely wooded by them, with scarcely any admixture of deciduous trees. The Pine-barrens of North America and the belt of Conifers in Northern Europe and Asia stretch almost continuously across the two continents, ceasing only with the limits of vegetation.

Notwithstanding the enormous areas still occupied by Coniferæ, instances are abundant of the areas of their growth and number of individuals becoming very sensibly lessened through contact with man or from changes of climate. The extinction of *Abies pectinata* and *A. excelsa* in England was probably due to a failure of heat. The diminution of *Taxus baccata* (the Yew) in England, and of many once common Pines and Firs in France, Switzerland, and Spain, the Cedars in Lebanon, and of the native Juniper and Yew in Madeira, are due to the agency of man. The limit at which Conifers cease to grow in Alpine forests in Switzerland is everywhere retreating towards the valleys, for Pines are not dwarfed there towards their superior limits, and do not creep as bushes to the verge of the snow-level as on other mountain ranges and towards the poles; but isolated and grand old Pines and Larches stand out in exceptional vigour beyond the rest. In many of these regions remains of large trees exist far above the limits of present forest vegetation; and the names of some now bare heights and valleys indicate their former wooded nature. In Siberia, on the other hand, the Larches seem to be creeping still farther north as trailing shrubs, and are now among the hardiest trees in existence.

Their majesty, symmetry, or fairy grace, their resinous fragrance, and their dry and open character give to Coniferous forests a charm seldom possessed by the often bare or dankly decaying forests of deciduous trees.

The stupendous size that individual Conifers attain has long excited wonder, though this is actually understated in text-books. Specimens have been seen of *Abies Douglasii* 309 feet in height, *A. Menziesii* 318 feet, *Picea grandis* 321 feet, *P. nobilis* about the same, *Pinus Lambertiana* 300 feet, and *Thuya gigantea* 325 feet; while the *Sequoias* are reputed to reach 400 feet, exceeding every forest tree in solid masses of timber. The Himalayan Pine and Deodar reach 200 feet; and some of the Podocarps of New Zealand also attain that height; while the Chilian Araucaria is said to exceed 260 feet. In Europe the extreme height recorded for any Conifer is 180 feet, the common Spruce and the Silver Fir both being stated by Selby to have attained these magnificent proportions. The age attained by some Coniferæ is no less astounding; a Taxodium, 117 feet in circumference, being inferred by De Candolle to exceed 5150 years in age, the Sequoia 4000, the Yew and Cypress about 2000, and Pines, Firs, Larches, and Cedars 300 to 500 years.

The economic value of the Coniferæ surpasses that of all other forest trees together,

supplying the largest proportion of useful timber, the importations of Coniferous wood into this country alone being of the value of £9,000,000 per annum. In India the Deodar takes the place of the Pine, and in the Southern Hemisphere the timbers of Araucarias and Dammaras are employed to a relatively equal extent. Many of the woods possess an intrinsic value for the manufacture of furniture, musical instruments, &c., tables made of the mottled butt-wood of the North-African Callitris having, according to Pliny, fetched £9000 or £10,000 each. The seeds of many Coniferæ are eaten or used for various purposes; and the annual importation of Coniferous tars and resins into England falls little short of £1,000,000 in value.

Tribe I.—CUPRESSINEÆ.

These are large, very resinous trees or shrubs, with small scale-like leaves, and small globular cones, composed of from four to eight, or rarely ten, peltate, persistent scales, except in the Juniper, where they coalesce into a fleshy berry called a *galbulus*, with numerous small, compressed, frequently triangulated seeds, usually provided with membranous wings at the angles. Both fruit and foliage, from their resinous nature, appear exceptionally capable of resisting decay in water. Thirteen genera and 111 species are described in Gordon's 'Pinetum' (1880), but Bentham and Hooker have since reduced the genera to seven, with twelve subgenera or sections, and seventy-five species. These range from Australia, through India and South America, to the Arctic regions; and while many are fitted to thrive in the subtropics, others, as species of Juniper and Cypress, are among the hardiest shrubs in existence.

Their origin can be traced back to the Permian if *Ullmannia* be really Cupressineous; and they became during the Jurassic and Wealden a preponderating tribe. Some of the forms are of interest, among them being *Widdringtonia*, *Echinostrobus*, *Thuyites*, and *Thuyopsis*, but all are more or less imperfectly known, and the abundance of the tribe is chiefly inferred from the prevalence of wood called *Cupressinoxylon*.

In the Cretaceous deposits a number of very anomalous forms are met with, combining the imbricated foliage of the Cupressineæ with characters no longer met with in the tribe. A remarkable form from Aix-la-Chapelle combines a *Libocedrus*-like foliage[1] with a cone resembling that of *Sequoia gigantea*, but under each scale are a number of Cupressineous seeds. In the Komeschichten of Greenland an important genus, *Inolepis* of Heer, combining imbricated foliage with small oval cones, composed of some forty leathery, dorsally-carinated, scales, seems more nearly allied to the *Taxodieæ*. An equally abnormal Cretaceous genus is *Cyparissidium*, which also possesses imbricated slender foliage and small ovate cones, composed of eighteen to

[1] Dr. De Bey supposes the foliage to be dimorphic.

twenty overlapping, leathery, longitudinally-ribbed scales. *Sphenolepidium Kurrianum*, apparently common in the Portuguese Cretaceous, has very finely imbricated foliage, and cones apparently smaller, but not dissimilar to the last. It would thus appear that the Cupressineæ were not completely differentiated until the Eocene Period.

The tribe is not abundantly represented in European Tertiary strata until the Miocene age; but it appears even rarer in the great series of Arctic floras described by Heer,—a singular fact, as most of them are now only adapted to temperate climates of the Northern Hemisphere. The presence of *Libocedrus* is alone well ascertained there; *Thuyites*, *Thuyopsis*, and *Widdringtonia* being founded on very fragmentary and almost unique twigs.

A few of the Cupressineæ, namely, some Cypresses and Junipers, inhabit swamps or places liable to inundation, while other species of the same genera seek out the loftiest mountains, and excel almost all other shrubs in hardiness, Juniper and Cypress being found in Central Asia at altitudes of 15,000 and 16,000 feet. The Juniper is the most hardy, creeping, as low scrub-bushes, on most mountain chains to far beyond the limits of trees, and occupying to the south the barren rocks of Cape Horn (*J. uvifera*), and to the north penetrating Labrador, Newfoundland, Hudson's Bay, and Greenland (*J. canadensis*). Some appear to adapt themselves to a great range of climate. *Fitzroya*, a stately tree 100 feet in height on the western slopes of the Patagonian mountains, dwindles to a small bush a few inches high on the confines of perpetual snow; and the Chilian *Libocedrus*, 100 feet high on the Cordilleras, dwarfs to a small bush in Magellan.

Although of relatively less bulk than the Sequoias and Pines, some species attain colossal dimensions, as the Oregon "Red Cedar" (*Thuya gigantea*), a plank of which was exhibited in the Philadelphia Exhibition from a tree 325 feet high and 22 feet in diameter; *Libocedrus decurrens* exceeds 200 feet; and the Himalayan *Cupressus torulosa* has been met with 150 feet in height.

The woods of several of the species are valuable;[1] and many of the gums, balsams, and resins are their products.

Of the seven genera[2] recognised in the 'Genera Plantarum,' FITZROYA alone has not yet been found fossil; and ACTINOSTROBUS is at present represented by a single cone from Sagor.[3] The very extensive genus JUNIPERUS, present in every geographical

[1] The mottled butt-wood of *Callitris quadrivalvis*, the "Thuya" of Pliny and "Citrus" of Horace, commanded fabulous prices during the Roman Empire. Cicero is said to have paid a million sesterces (£9000) for a table made from this wood; and of two tables belonging to King Juba, and sold by auction, one fetched 1,200,000 sesterces, although the largest recorded diameter was only about fifty-four inches.

[2] *Widdringtonia*, *Frenela*, *Chamæcyparis*, and other generic names frequently made use of in works on fossil plants, are treated by Hooker and Bentham, whose classification is here followed, as subgenera.

[3] The specimen described by Ettingshausen in 1859 is ignored by Schimper in his 'Paléontologie Végétale.'

region except the Australian, is divided into three sections. It is recorded as fossil from Aix, Häring, and the amber-beds of Prussia; but the small size of the fragments known, and the absence of fruit, render the determinations somewhat doubtful. The same species is supposed by Saporta to have persisted in Provence to the present day. A few fragments from the Upper Cretaceous of Greenland are known; and *J. rigida*, from the Tertiary of Spitzbergen, is based on an indistinct mutilated fragment, three quarters of an inch long. Its comparative rarity in the Arctic fossil floras is remarkable.

The foliage of Thuya is imbricated like that of Libocedrus but is less symmetric, and the cones are small, leathery, oblong, or oval, and of six to ten valvate unequal scales, persistent and gaping after shedding seed. The species are divided into five sections, and some attain gigantic dimensions. They inhabit principally North America, Japan, and China. No remains are known below the Tongrian beds of Armissan, where they are rare. Saporta, who has described them, believes the species *T. europœa* to be intermediate between *Thuyopsis dolobrata* and *T. borealis*, and from the identity of the foliage considers it the same as that which is included in the amber-beds in the north. Thuya, which formed vast forests on the Baltic during the latest Miocene, becomes plentiful to the south in the Pliocene deposits of Tuscany and Marseilles. *T. europœa* is claimed by Heer as an Arctic fossil on the strength of a terminal shoot, only three quarters of an inch long, from Atanekerdluk; and other species, *Thuyites Ehrenswærdi*, *T. Meriani*, and *T. Pfaffii*, are based upon no better material. Bowerbank supposed his *Cupressinites crassus* from Sheppey to be near *Thuya orientalis*. The widespread conifer, formerly known as *Chamœcyparis Hardtii*, of European Eocenes, is now recognised to be a *Sequoia*.

The three remaining genera are represented in the British Eocenes.

Genus—Callitris.

Flowers monœcious or rarely diœcious, terminal. Cone globose or conical; valves three to six, rarely eight, even, or every alternate one larger, woody, persistent, dehiscent when ripe; seeds numerous, oblong, crustaceous, two to three-winged. Leaves scale-like and imbricated, or rarely acicular on the sterile branches.

The genus, as it now exists, is subdivided into four sub-genera, of which only certain characters need here be referred to.

1. Pachylepis, or *Widdringtonia*, distinguished by thick woody cones, with four sub-equal valves. Confined to South Africa and Madagascar. Species 3.

2. Tetraclinis, or true *Callitris*, cones with four valves. Confined to North Africa. Species 1.

3. Hexaclinis, or *Frenela*, cones with six scales, three of which are smaller than the rest. Confined to Australia, except one New-Caledonian species. Species 9.

4. Octoclinis, cones with eight valves. Limited to a single Australian species. Species 1.

The Eocene species seem to present much greater variation in the number of valves or scales than the existing species show; and Miller also has discovered in the Australian Miocene, a genus with large fruits, *Spondylostrobus*, in which the valves vary from four to six.

Callitris, at the present day, comprises, according to Bentham and Hooker, but fourteen species, though Gordon, in the 'Pinetum,' enumerates twenty-six. Many authors limit the genus to the *Tetraclinis* section as defined on the preceding page.

The genus does not appear to be older than the Tertiary Period. The earliest forms are from the London Clay of Sheppey, and the Calcaire-Grossier of the Paris Basin, and belong to the third or Frenela section. The *Tetraclinis* section appears almost contemporaneously, two very distinct types being known; one from the Eocenes of Aix and St. Zacharie, in Provence; the other from Switzerland, Bohemia, &c., where cones are very frequently found attached to the branches. *Widdringtonia* again occurs in the Amber of Samland.

A considerable number of supposed Callitris fruits from the London Clay of Sheppey were described by Bowerbank under the name of Cupressinites. A few of these seem to be true Callitris. The species are as follows:

Cupressinites globosus, Bow., 'Foss. Fruits and Seeds of the London Clay,' 1840, seems to be deficient in Cupressineous characters. Bowerbank describes it (op. cit., p. 52) as formed of an inner and an outer cupula, the outer being cup-shaped and fleshy, and the inner enveloping "the seed so closely as usually to leave but a very small portion of its apex visible through the triangular opening at the apex of the fruit." The inner cupula is composed of three valves, which are described as being cleft for only two thirds of their length. The specimens now in the British Museum, and others which I have since obtained, appear to present a rather thin tripartite husk, articulated to a cupula, and inclosing a single large fruit or seed. One specimen (op. cit., pl. x, fig. 14) is, however, very different to the rest, and might possibly belong to *Callitris*.

C. elongatus, Bow., op. cit., p. 54, is similar to the above.

C. recurvatus, Bow., op. cit., p. 55, appears to be another example of the fruit erroneously figured as *C. globosus*, pl. x, fig. 14, referred to above, and may equally be a *Callitris*. The original unfortunately no longer exists.

C. subfusiformis, Bow., op. cit., p. 56, possesses no Cupressineous characters. The original is still preserved in the British Museum.

C. curtus, Bow., op. cit., p. 56, is now described under Callitris.

C. Comptonii, Bow., op. cit., p. 57, is included with the last.

C. crassus, Bow., op. cit., p. 59, is also included in the description of *Callitris*.

C. thujoides, Bow., op. cit., p. 58, with last.

C. subangulatus, Bow., op. cit., p. 60, is here described as CALLITRIS.

C. corrugatus, Bow., op. cit., p. 61 (*Solenostrobus*, Endlicher), is founded upon a very indistinct specimen (now in the British Museum), each valve of which seems subdivided. It has no distinctly Cupressineous character.

C. sulcatus, Bow., op. cit., p. 61 (*Solenostrobus*, Endl.), is a five-valved fruit, the original of which has not been identified. It suggests no Cupressineous affinity.

C. semiplotus, Bow., op. cit., p. 62 (*Solenostrobus*, Endl.). This somewhat resembles the preceding form, but cannot now be found.

C. tesselatus, Bow., op. cit., p. 63. The small specimen figured (pl. x, figs. 30 and 31) is very indistinct, but possesses five scales, articulated at the base, and with traces of a central plate. It does not appear to be Cupressineous; but figs. 26 and 27 of the same plate and species are here referred to under *Callitris curta*.

The cones in several of the existing species are exceedingly variable in size and appearance, so much so that it might even be possible that the two species to be described, totally unlike as they appear, may eventually have to be united.

1. CALLITRIS CURTA, *Bowerbank* sp. Plate IX, figs. 7—21.

CUPRESSINITES CURTUS, C. COMPTONII, C. THUJOIDES, C. CRASSUS, *Bowerbank*. Foss. Fruits and Seeds of the London Clay, pp. 56—59, pl. x, figs. 9, 20—23, 34, 1840.

CUPRESSITES CURTUS, &c., *Unger*. Synopsis Plant. foss., p. 192, 1845.

CALLITRITES CURTUS, C. COMPTONI, C. THUJOIDES, HYBOTHYA CRASSA, *Endlicher*. Synopsis Conif., pp. 274, 275; Goeppert, Monogr. der foss. Coniferen, pp. 170—180, 1850; Unger, Gen. et Spec. Plant. foss., p. 345, 1850.

CALLITRIS CURTA, C. COMPTONI, HYBOTHYA CRASSA, *Ettingshausen*. Proceed. Royal Society, vol. xxix, p. 392, 1879.

London Clay, Isle of Sheppey.

The cone is conical, and consists of four, five, or rarely six valvated scales. These valves are sometimes very unequal, but more often sub-equal, very thick and ligneous, more or less obtusely pointed, rugose, and somewhat keeled exteriorly, and apparently smooth and concave on the inside. No distinct umbo is preserved, but all are to some extent water-worn. All those preserved are dehiscent, and partly filled with pyrites, only one exhibiting the summit of the central column. The foot-stalk is thick. The cones are variable in size, the largest measuring two centimètres in diameter, and many are slightly distorted.

In spite of the varying number of scales I can see no characters by which those species described by Bowerbank, enumerated above, can be separated; for it is note-

worthy that nearly all fossil Callitres show a great amount of variability in this respect, relatively to recent species. Bowerbank's species were founded on unique specimens; but now that these are supplemented, the connection between them has become apparent. All those still preserved have gaped and shed their seed before fossilisation, but Bowerbank had before him an example in which the valves were still closed.[1]

This type of *Callitris* belongs to the *Frenela* section, and is most nearly represented at the present day by *C. australis*, a tree growing sixty or seventy feet high, and found on the East Coast of New Holland and in Van Dieman's Land, and by *C. robusta*. I have observed many of these trees thoroughly acclimatised in Madeira, and find that the cones are very abundant, and in some species exceptionally persistent after shedding seed, remaining in rings or clusters on the thick branches, and even round the trunks, from which they can only be detached by aid of a sharp knife. None were lying under the trees, and only solitary cones on comparatively slender foot-stalks could possibly get removed, so that even in districts where the tree grows thickly no fruits of some of the species would be deposited amongst other vegetable remains. The normal number of six valves, three of which are almost always less developed, is not infrequently reduced to five.

Fig. 5.—*Callitris australis.*

These fruits are rare at Sheppey, about one in 2000; and their determination is so far satisfactory that they can be referred to no other section of the Coniferæ. Ettingshausen was mistaken ('Proceedings Roy. Soc.,' 1879), in supposing the species occurs at Alum Bay; the fruit accepted for it being oval, smooth, with only two valves, and on a slender, naked, dichotomous stem, and therefore quite unlike any fruit of the Cupressineæ. Fruits with three, four, and five valves are figured from Sheppey, the last being the most abundant.

Callitris Ettingshauseni, sp. nov. Plate IX, figs. 1—6.

London Clay, Isle of Sheppey.

The cone is nearly globular, twelve to fifteen millimètres in diameter, composed of either six or eight valvate scales, every alternate one being oblong obtuse, and the rest short oval-lanceolate, and also obtuse, forming at the apex a tesselate cruciform design, which is striking and distinctive. The arrangement of the valves is identical with that of the closed cones of some species belonging to the section *Frenela*, and like no other known

[1] This, described as *C. Comptonii*, was from the Marquis of Northampton's collection, and, together with those formerly in the Canterbury Museum, no longer exists. All the other originals are in the British Museum.

fruits, so far as I can learn,[1] the resemblance being so complete in form and size as to render it certain that they are, if not the same, at least closely allied to the existing species. In comparing the characters of the fossil and the recent examples in detail, the condition of fossilisation has to be considered. When ligneous fruits occur fossil in the London Clay, the whole of the ligneous tissue is not replaced by pyrites, for an outer and sometimes several inner coats of lignitic matter remain, but the outer skin on drying bursts and rapidly peals off, so that it is rarely preserved in specimens picked from the beach, even when they have not been rolled by the sea. The removal of this outer coat has left these specimens much smoother than the recent Frenela fruit, and in addition they have been water-worn. The outlines of the valves are marked by grooves, due to the greater thickness of the lignitic layer round their edges, corresponding with the thickening in recent Frenelas, and the small scars at the base appear also to mark the dove-tailing of the valves into the axis, which is partially effected by two twin spur-like projections. The scar near the termination of the valves is similarly due to a small spur of woody tissue. The fruits seem partly hollow, and the seeds, with which the living fruit is filled, cannot be made out; but the rough division into four cavities, shown by the abrasion of the base in one of the specimens (Pl. IX, fig. 2), agrees fairly well with what would appear if a recent cone were infiltrated with pyrites. The removal of parts of the smooth surface from other specimens discloses an inner granular structure, which has probably replaced the seeds. The determination cannot be regarded otherwise than as satisfactory.

FIG. 6.—Cone of *Callitris Endlichleri*. Side.

FIG. 7.—*Callitris Endlicheri*. Apex.

Callitris Endlicheri is perhaps the most closely related species, and is described as an evergreen bush, with loose subterete branches, crowded with somewhat slender three-edged branchlets, found in the interior of the eastern part of New Holland and about Port Jackson.

C. Ettingshauseni is rare in the London Clay of Sheppey, about one in 2000 specimens, and has not previously been recorded. The cones are closed, as are the greater number of those of the existing species that I have seen preserved in Herbaria. It presents another most interesting example of variation in the number of scales, in a species in which they do not appear to vary at the present day. Five specimens are figured.

The North-African type, which has been identified in great abundance in European Eocenes, especially towards the south, is not yet known to occur in England, though the foliage from Bromley, here referred to Libocedrus, bears a great resemblance to some of the foliage from other Eocene localities, referred to Callitris. There is a considerable

[1] The determination was approved by all the authorities at the Kew Herbarium, including Sir J. Hooker and Prof. Olliver, to whom I have submitted it. Other species of Frenela resemble it, but less closely.

difference in size between the Häring, Radaboj, and Armissan specimens of *C. Brongniarti*, and still smaller specimens from St. Zacharie are described as *C. Heerii*.

C. Brongniarti (Goeppert, 1836[1]) is closely related to the existing *C. quadrivalvis;* and is highly characteristic of the later Eocenes and Oligocene of Central Europe, for it appears to have grown on all the shores of the Eocene Mediterranean Sea. Its area has, according to Saporta,[2] become more and more circumscribed, until at the present day it seems to have taken refuge only in the most southern portions of its former habitat, the existing species being now confined to the Mountains of Barbary and Mount Atlas. It loves rocky situations and a warm dry climate in proximity to the sea, and Saporta hence infers that the Eocene climatic conditions of Aix resembled those of Barbary or Abyssinia. There can hardly be a doubt but that the humidity of climate, evidenced by the flora, excluded it during the middle and later Eocene periods from the British area.

Genus—Libocedrus.

The genus Libocedrus is readily distinguished by its small, flattened, ovate, or oblong cone, composed of four to six hard leathery valves, very unequal, and in opposite pairs, not overlapping, and with small recurved terminal points. These cones are deciduous, and have not yet been met with fossil. The flowers are separate and terminal, and the seeds winged and samaroid, the valves of the cone remaining widely gaping. The foliage is no less characteristic, being thick and scale-like, and the leaves compressed in opposite pairs, and regularly imbricated in four rows. The genus, which occasionally forms very large trees, is widely distributed, two species being met with in Chili, two in New Zealand, and the rest in China, Japan, and California. Most of these grow at considerable altitudes, some even reaching the snow-line. Only three fossil species have been described, two of them from the Tertiaries. Of these *L. salicornioides*, a very characteristic species, has been met with in the Tongrian at Armissan, Ménat, &c., at Bilin, Radaboj, Schœnegg, Leoben in Styria, in Austro-Hungary, at Bonn, and in the amber-beds of Prussia, Monod in Switzerland, and Sinigaglia in Italy. It is compared to *L. chilensis*. Another species has been recognised by Heer in the Eocene of Spitzbergen, and appears to resemble *L. andina*, a tree confined to the cold valleys of the Andes. There is some evidence of a second and larger Arctic species, but the material is hardly satisfactory. The remaining species is from the Upper Cretaceous of Greenland, whence a very singular and apparently allied genus, *Moriconia*, has also been obtained.

[1] It first appears in the Calcaire Grossier of the Trocadero and Arcueil, near Paris, at Aix, St. Zacharie and Armissan (Saporta), and at Häring, Radaboj, Schossnitz, Sagor, Koumi; its most northerly range having been Salzhausen, in the Wetterau, latitude 51° 24′. The foliage in most localities is abundant, and the fruit often attached.

[2] "Révision des Flores d'Aix," 'Ann. des Sciences Nat.,' 5 série; 'Botanique,' vol. xv, 1872, pp. 39, 50—53.

LIBOCEDRUS ADPRESSA, sp. nov. Plate II, figs. 17—20.

Woolwich beds, Bromley.

The leaves are small, scale-formed, in alternate opposite pairs, compressed, adnate at the base, those on the margin clasping both sides, those on the upper and lower sides flat, and with more or less acute apices. The branching is irregular, and takes place by dichotomy similar to that in *Libocedrus decurrens*, the number of the leaves increasing to three or four pairs at the base of the forks. The longest leaves, 15 millimètres, are situate towards the bases of the branchlets, becoming shorter towards the buds.

The foliage appears to be identical in every respect, except that it is somewhat broader, with the existing *Libocedrus decurrens*. It differs from the more shortly imbricated species known as *L. salicornioides*, from Bilin, Armissan, Sinigaglia, &c., but bears a considerable resemblance on the other hand to some of the larger foliage ascribed to *Callitris Brongniarti*, from similar localities.

In the absence of any organs except foliage the determination of this fossil must be open to some doubt, for not very dissimilar foliage is met with in Thuya, Cupressus, Callitris, and even other genera. The strong resemblance, almost amounting to identity, between it and *Libocedrus decurrens* however, and the subordinate characters in the foliage of both, which serve to distinguish them from all other species of Coniferæ, induce me to place the fossil in Libocedrus with some confidence.

FIG. 8.—*Libocedrus decurrens*. Nat. size.

Libocedrus decurrens, or the Incense-cedar, is one of the giants of the Sierra Nevada. It is very generally distributed throughout the forests of the Yosemite, without exclusively occupying any area, or even making extensive groves. Its most congenial climate is on the warmer hill-sides, at elevations of 3000 to 4000 feet. The largest specimens are about 150 feet high, and 6 or 7 feet in diameter. The branches spread out horizontally, in beautifully fronded, ferny plumes, becoming erect at the summit and drooping towards the base of a singularly striking and regularly cone-shaped tree.

The foliage of *L. adpressa* is known only from Bromley, where, though not rare, it is very locally distributed.

GENUS—CUPRESSUS.

The genus CUPRESSUS, or Cypress, comprises twelve or more distinct species, with imbricated foliage, and small, woody, globular cones of six to ten peltate scales, armed with a central point or umbo. Most of the species are natives of comparatively warm climates,

and inhabit Southern Europe, China, California, Mexico, Guatemala, North America, and the East Indies. Some form stately trees, exceeding even 150 feet in height. Hitherto it has only been known fossil from two Miocene localities in Germany, and from Antrim and Italy; but in the latter cases especially the determinations appear founded on wholly insufficient material.

CUPRESSUS TAXIFORMIS, Unger, sp. Plate I, figs 1—13; Pl. V, figs. 13, 14; Pl. VII, fig. 8; Pl. IX, figs. 22—26, 28—30.

TAXITES ACICULARIS, *Ad. Brongn.* Prodrome des plantes foss., Calc. gross., Descr. Env. de Paris, p. 362, 1828.

CUPRESSITES TAXIFORMIS, *Unger.* Chloris Protogæa, p. 18, pl. viii, figs. 1—3; pl. ix, figs. 1—4, 1847.

— — *De la Harpe.* Mem. Geol. Survey, Isle of Wight, p. 111, pl. v, fig. 2, 1862.

Middle Bagshot, Bournemouth.

The cones are ligneous and subglobose, broader than high, and 12 to 16 millimètres in diameter. The scales are eight in number, in four unequal pairs, subangular, four- or five-sided, depressed, and with strong wrinkles converging towards a sub-central mucro, and with slightly thickened and recurved edges. The four basal scales are sometimes trilobate and always coalesce into a single unequal quatrefoil round the foot-stalk, one pair, however, being relatively shortened. The next pair are opposite and five-sided, and the uppermost pair rather smaller, quadrate, and sometimes soldered together.

The foliage is polymorphic. In the young and barren shoots it is spiral, but with two lateral rows of leaflets expanded, and the rest decurrent and relatively undeveloped. The expanded leaflets are linear, rarely linear-lanceolate, from 3 millimètres to 15 millimètres in length, opposite or alternate, seldom crowded or overlapping, with acute, sometimes mucronate, symmetric, or more often asymmetric apex and indistinct midrib. This type, though generally separate, occasionally passes into the ordinary imbricated foliage on the same shoot. The scale-like foliage is loosely imbricated and of various shapes, spiral, in apparently six rows, sometimes short and acute or obtuse-pointed, or longer, adpressed, and decurrent, awl-shaped, blunt, or acutely pointed, and occasionally spinous.

The leaflets are very persistent to the stem, less expanded than in *Sequoia polymorpha*, more pointed, and of more delicate texture, more regular and expanded than in *Glyptostrobus*, and less crowded than in the Alum Bay Podocarp. The shoots or branchlets were shed simple, for among many I have rarely seen one compound. The longest is 12 centimètres in length, but the average is only from 4 to 6 centimètres.

These characters enable the foliage at Bournemouth to be distinguished with some certainty, though it would be less easy to identify it from distant localities.[1]

The evidence favouring its reference to *Cupressus* is that cones, identical except in some minor characters, with cones of an existing species are found in the Marine Beds at Bournemouth with the same foliage; an identical cone and other fragments of cones (Pl. IX, figs. 28, 29; Pl. V, fig. 14) being also associated with the foliage in the fluviatile beds. The imbricated foliage is thus absolutely connected with true Cypress cones. The more leafy foliage is seen on several of the figured specimens (Pl. I) to be joined to this, and their constant association together, in at least all the freshwater beds in which either occur, would alone render it far more probable that they belong to the same than to different conifers.

Male flowers, probably of this species, are figured (Pl. I, fig. 12, and enlarged at 12 *a*), and small pellets of amber are frequently associated with the twigs.

The species is not met with at Bournemouth lower than the horizon of rolled blocks marked *i* in the Coast Section ('Quart. Journ. Geol. Soc.,' vol. xxxviii, p. 4, 1882, "Description of the Bournemouth Beds," part 2), in some of which it occurs abundantly mixed with broken cones, the distichous foliage being finer and (Pl. V, fig. 13) more sharply pointed in these than at higher horizons. It is quite absent from the beds called Gleichenia-beds in the section, and from all the "Lower Coastguard-beds," but suddenly reappears in great abundance in the highest bed immediately under, and continues throughout the "Black Bed." Here, wherever the clay is fissile, large sheets may be obtained thickly sprinkled with its shoots, mingled with much macerated leaf matter, seeds, &c. (Pl. I, figs. 1 and 2).

De la Harpe figured a specimen in the 'Geological Survey Memoir on the Isle of Wight,' identifying it with Unger's *Cupressites taxiformis* from Häring, in the Tyrol. Some of the foliage from other parts of Europe, determined as *Sequoia Hardtii*, &c., may not improbably belong to this species.

The cones are so distinctly those of the Cypress,[2] that no doubt whatever as to their genus can be entertained. Their wrinkled mucronate surface and rectangular form, together with their base formed of four scales soldered together, is reproduced in such well-known species as *C. sempervirens*, *C. torulosa*, *C. macrocarpa*, and *C. funebris*. The latter species, indeed, further resembles our fossil in the possession of not dissimilar dimorphic foliage. This character appears, as in the Taxodieæ, rarer in existing than in fossil species, and is only shared by two species of *Callitris* and some imperfectly known

Side. Base.

Fig. 9.—Cone of Cypress (*Cupressus sempervirens*).

[1] The fig. 1 D of *S. polymorpha* on pl. ii of the second part of Saporta's 'Études sur la Végétation,' seems to be of this species, for not only is the foliage identical in the minutest details, but the cone attached is represented with the peculiar trefoil-shaped scale at its base, and with the number and arrangement of scales characteristic of this Cupressus.

[2] Fig. 27, pl. xi, is apparently another species, and more resembles some of the *Sequoia Couttsiæ* from Bovey.

Widdringtonias and Cypresses in Mr. Gordon's collection, recently purchased and presented to the Kew Herbarium by Sir J. Hooker.

The only genus resembling Cupressus is the closely-allied Thuya. The cones, however, are generally smaller and are more leathery, except in the section Chamœcyparis or Retinospora, in which they are woody and only distinguishable in size from those of Cupressus. All the Thuyas have imbricated foliage except the section Biota, in which it is sometimes partially expanded.

Fig. 10.—*Retinospora filifera.*—From Veitch's 'Manual of the Coniferæ, p. 244.

Cupressus funebris, or the funeral cypress, is when full grown a graceful tree, with erect stem and drooping branches, reaching a height of fifty or sixty feet. The young plant is of erect habit, and is clothed with needle-like leaves, which are succeeded as it becomes older by others which are scale-like, closely adpressed, and imbricated. It is a native of the north-east provinces of China, and frequently appears in clumps on the sides of hills. The other species to which the fossil has been compared, on account of the similarity in the cones, are natives of eastern Europe, the Himalayas, and California.

Tribe II.—THE TAXODIEÆ.

The genera are *Cryptomeria*, *Taxodium*, *Sequoia*, *Athrotaxis*, and *Cephalotaxus*, possessing spiral or distichous foliage, and smooth, woody, or leathery, more or less ornamented cones, except in the last which bears a drupe. All the genera are alike remarkable for the paucity of their living species, which in no case exceed four, and for the restricted areas which these occupy. It would appear from this, and their much wider range in the Tertiaries, that they are survivals from older floras. All are natives of temperate North America, or China and Japan, except the Tasmanian *Athrotaxis*.

The Permian *Ullmannia* is the oldest genus ascribed to the Taxodieæ, but its true affinities are still somewhat doubtful. A specimen with cones attached, from Solenhofen, was originally described as *Athrotoxis*, but was transferred by Schimper to the Jurassic genus, *Echinostrobus*. Other Jurassic and imperfectly known genera, *Brachyphyllum* and *Leptostrobus*, have been placed in this tribe. Its first definite appearance seems to date from the Middle Cretaceous, cones with at least the outward semblance of *Sequoia* having been obtained in the Gault and Greensand. From the Greenland Komeschichten, besides *Sequoia*, a genus *Inolepis*, with imbricated foliage and cones of some forty leathery, dorsally-carinated scales, which are very like the male cones of *Sequoia* (fig. 13, p. 33), is abundant, and has been, I believe, erroneously placed in the Cupressineæ instead of near to *Glyptostrobus*. Another remarkable form from Pattorfik and the Upper Cretaceous of Europe, especially Portugal, and which should also be placed in this tribe, is *Cyparissidium*, also possessing imbricated foliage, and small ovate cones of eighteen or twenty overlapping, leathery, and longitudinally-ribbed scales. A single but very characteristic scale of *Glyptostrobus* from the beds at Pattorfik suffices to carry that genus back to the Cretaceous. The Wealden *Sphenolepidium* appears somewhat remotely allied to *Cryptomeria*, and the Cretaceous *Geinitzia* to *Sequoia*. The existing genus Cephalotaxus may probably be represented in the Arctic Eocenes by *Taxites Olriki*. Cryptomeria, which forms a tenth part of the forests clothing the three large islands of Japan, is at present unknown in the Tertiaries. The genera *Taxodium*, *Sequoia*, and possibly *Athrotaxis*, are represented in British Eocenes.

Genus—Taxodium.

In this genus the flowers are monœcious, the cones globular and ligneous, and persistent after shedding the seed, the scales spirally disposed, imbricated, with an expanded ligneous, mucronated or umbonated apex, and tuberculated or embossed margin. The foliage is deciduous or sub-persistent, distichous, or small and scale-formed. There are

three existing species, *T. distichum*, or the deciduous Cypress, *T. mexicanum*, which flourishes on the high plateau of Mexico at from 5750 to 7670 feet above the sea, forming trees 120 feet in height and 25 to 40 feet in girth,[1] and the smaller *Glyptostrobus* of Japan.

The *Glyptostrobus* section of *Taxodium* is said to occur in the Tertiaries of Atanekerdluk in Greenland, and of the Mackenzie River, Spitzbergen, and Alaska. Of two species described, one has only imbricated and the other imbricated and distichous foliage, but no trace of the cones of *Glyptostrobus* has yet been obtained with either. There is, indeed, no direct evidence that any of the foliage so described from the Arctic Tertiaries does not belong to the Sequoias, whose fruits are so constantly associated with it. The nearly invariably polymorphic growth of the ancient Sequoias has not been sufficiently recognised, and hence every polymorphic twig has been placed in the genus *Glyptostrobus*.

The inflorescence ('Fl. Foss. Arctica,' vol. iv, pl. 11, fig. 8), also determined as that of *Glyptostrobus*, is indistinguishable from that of *Sequoia*. The species had a very extensive range in Europe, principally from the Upper Eocene period to the close of the Tertiaries; for it is recorded from Greece, Italy, Austria, Switzerland, France, Germany, and as far north as the Baltic provinces. Foliage alone would be scarcely satisfactory evidence of its range, but cones accompany it at Koumi, in Eubœa, Hungary, Oeningen, Manosque, and the Prussian shores of the Baltic.

It finally disappears from Europe with the Pliocene of the Val d'Arno.

TAXODIUM EUROPÆUM, *Brongnt.* Plate III, figs. 1—9; and Plate IV, figs. 1—8.

TAXODIUM EUROPÆUM, *Brongnt.* Ann. des Sciences Nat., 1st series, vol. xxx, p. 175, 1833.
— ŒNINGENSE, *Al. Braun.* In Leonh. and Bronn., Jahrbuch, 1845.
CUPRESSITES RACEMOSUS, *Gœpp.* Monogr. Conif., p. 184, pl. 19, 1850.
TAXODITES EUROPÆUS, *Gœpp.* Ibid., p. 192, pl. 22, fig. 1, 1850.
GLYPTOSTROBUS EUROPÆUS, *Heer.* Fl. Tert. Helv., vol. i, p. 51, pls. 19 and 20, fig. 1, 1859.

Middle Bagshot, Bournemouth.

The foliage is usually imbricated, sometimes closely adpressed and decurrent, the leaflets of various shapes, alternate, some scale-like, small, ovate, acute or obtuse-pointed, others near the base of the shoots frequently very short and scale-like, somewhat triangular and compressed, increasing towards the points of the shoots to rather long, awl-shaped, and recurved, and even expanding into flat linear leaflets, tapering to a sharp point. The branchlets appear to have been alternate, somewhat crowded, and repeatedly forking, and the shoots frequently seem to terminate in a male flower or bud.

[1] Humboldt, 'Cosmos,' p. 326.

No trace of the fruit has been met with at Bournemouth, the branchlets to which the cones were attached having probably been floated farther out towards the sea. In their absence there is obviously no absolutely certain evidence as to the genus to which the foliage belongs, but the very great likeness it bears, not only to fossil foliage positively known to belong to *Glyptostrobus*, but to that of the existing species, renders it in a high degree improbable that the determination is incorrect.

The Bournemouth specimens are the oldest Eocene representatives of the genus, and most nearly resemble the form described by Ettingshausen as *G. bilinicus* from Bilin, a form subsequently incorporated by Heer in his species, *G. Ungeri*. Its discovery is interesting as it unites to some extent the species with decidedly polymorphic foliage (*G. Ungeri*) with the true *G. europæus*, in which the foliage is described as wholly imbricated. Foliage from a large number of localities has been ascribed to *G. europæus*, often apparently on a superficial comparison. Some imbricated foliage from the newest stage of the American Lignitic has been referred by Lesquereux to this genus.

Its remains are very abundant in the "Lygodium-and-Laurel-beds" at Bournemouth, whence a considerable branch (Pl. IV, fig. 1) has been obtained. It is also not unfrequent in the "Willow-bed," where it seems to put on a freer and less imbricated character (Pl. III, figs. 1—9). I have never yet met with it in any of the series of Leaf-beds at Bournemouth east of this point, nor in any other British Eocene formation.

The frequently branching character of the specimens enables this species to be distinguished easily from the other Coniferæ at Bournemouth.

The existing *Taxodium* (*Glyptostrobus*) *heterophyllum* is a small tree with an erect stem, growing from eight to ten feet high, confined to parts of China, and inhabiting preferably places liable to inundation or the banks of rivers. It has leaves of various forms, and is almost evergreen.

TAXODIUM EOCÆNUM, sp. nov. Plate VII, figs. 1—8.

Middle Bagshot, Bournemouth.

The foliage is usually minute, somewhat scale-like, but occasionally approaches a distichous arrangement. As in the last form, the expanded leaflets seem confined to young plants or shoots, and they are very slender, linear, and taper to an acute point. The more abundant foliage is imbricated spirally, the leaflets long and decurrent for some distance, and terminating in a more or less ovate and acute point. The branchlets were shed either in dense tufts, twelve to fourteen inches in length, or singly. The tufted branchlets probably formed the apex of the branches, and the simple branchlets, which reach seven or eight inches in length, were shed from the more woody regions. The immature fruits figured (Pl. VII, fig. 6) have the appearance of berries covered with small scales, and closely resemble some preserved in the Kew Herbarium from New Orleans. The

very delicate and partly distichous foliage shown in fig. 3 is also occasionally met with in the existing species.

The fossil differs very considerably from the ordinary forms of *Taxodium distichum*, but strangely resembles, even in very minute particulars, the variety *T. imbricataria*, Mett., which inhabits, as an inscription in the Kew collection states, "ponds in the pine forests of Florida." The length and slenderness of the branches in both cases suggest a somewhat pendulous habit, and the texture of the fossil leads to the belief that it was not very leathery, and of probably a brightish green.

Taxodium distichum forms very extensive forests. The Deciduous Cypress, as it is called, is described as towering over all the vegetation of the Great Dismal Swamp, with its top spreading in full leaf in the season when the sun's rays are hottest, and when, if not intercepted by a screen of foliage, they might soon cause the fallen leaves and dead foliage to decompose, instead of contributing to the peaty mass. The White Cedar, *Thuya sphæroidea*, forms a dense undergrowth, firmly supported by its long tap-roots in the softest part of the quagmire, whose surface is carpeted with Ferns and Reeds. The association of this with a Cypress in the "Coastguard-beds" at Bournemouth, and with many Ferns of the sub-tropics of North America, shows that it may have grown there in not altogether dissimilar stations.

While the most heat- and moisture-loving of all the forms of *Taxodium distichum* has never been met with elsewhere, and is, even at Bournemouth, limited to a single bed, other varieties of the same species are very abundant in European Tertiaries. The most familiar type of *Taxodium distichum* with distichous and deciduous leaves, that which withstands our own climate at the present day, has been met with fossil in the Tertiaries of Atanekerdluk, in Greenland, of Alaska, and Spitzbergen. Further south magnificent specimens have been obtained from the Miocene of the Baltic Coast, and figured by Heer as *T. distichum miocænum*. Two other varieties are met with, one of them, a Spitzbergen form named *T. angustifolium*, approaching nearer, according to Heer, to *T. mexicanum*. Foliage assigned to the Miocene *Taxodium distichum* is also stated to have been found at numerous localities, especially in the newer Miocenes of Austria, Italy, Switzerland, the South of France, and the United States; but, as cones are, in scarcely any instance, associated with the foliage some doubt about it still exists. There can, however, be no doubt that the temperate type of the species, after flourishing in the Arctic regions during the Eocene, descended, as temperatures decreased towards the close of the Miocene, as far as Central Europe and to the United States. That type is quite unknown in any Eocene deposit of temperate Europe, though *Glyptostrobus* is very universal. Sir Joseph Hooker[1] looked upon it as the most interesting of the Arctic fossils.

The Bournemouth species is wholly confined to the uppermost of the "Coastguard-beds" below the Black Bed, where it is associated with a luxuriant Flora.

[1] 'Ann. Add. Royal Society,' 1877, p. 10.

Genus—SEQUOIA.

The Sequoiæ are monœcious. Their cones are ovate, ligneous, persistent, and terminal on the branchlets, one to two inches in length, composed of sixteen to thirty-five wedge-shaped scales, with a wrinkled and depressed, transversely oblong, nail-like head, mucronated in the centre. In existing species they are solitary, but clustered in several fossil species. The foliage is distichous and yew-like in *S. sempervirens*, and spirally imbricated in *S. gigantea*, though both occasionally foliate in the opposite way. These are the only existing species of a genus which was widely spread during the Tertiary

FIG. 11.—Cone of *Sequoia sempervirens*. (Figs. 11—14 are from Veitch's 'Manual of the Coniferæ.')

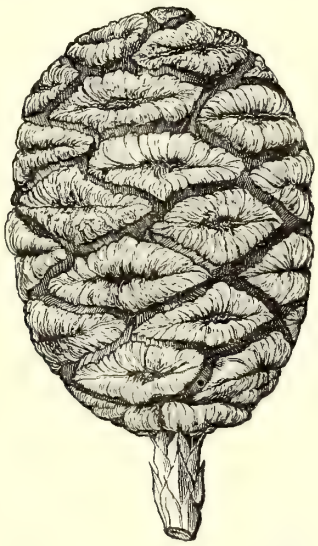

FIG. 12.—Cone of *Sequoia gigantea*.

FIG. 13.—Male flowers, *Seq. gigantea*.

FIG. 14.—Male flowers, *S. sempervirens*.

period. The former, better known as the Red-wood, occupies the Coast Range, a sandy ridge rising to a height of 2000 feet, and forms dense forests, twenty to thirty miles in width, from a little south of Santa Cruz to the southern borders of Oregon, following the coast-line for some 350 to 500 miles; its distribution depending according to Professor Bolander, upon the sandstone and oceanic fogs. The second species, *S. gigantea*, extends at intervals along the western slope of the Sierra Nevada for nearly 200 miles, and at elevations of from 5000 to 8000 feet. "Towards the north the trees occur as very small, isolated, remote groves of a few hundreds each, most of them old, and interspersed amongst gigantic pines, spruces, and firs, which appear as if encroaching upon them. Such are the groves visited by tourists (Calaveras, Mariposa, &c.). To the south, on the contrary, the Big-trees form a colossal forest forty miles long, and three to ten broad, whose continuity is broken only by the deep sheer-walled cañons that intersect

the mountains; here they displace all other trees, and are described as rearing to the sky their massy crowns; whilst seen from a distance the forest presents the appearance of waves of vegetation, gracefully following the complicated topography of the ridges and river-basins which it clothes."[1]

The oldest Sequoias known are those described by Carruthers from the Blackdown beds and the Folkestone Gault. Schimper speculates upon their derivation from some much older Araucarian form, and the character of the foliage associated with them in Cretaceous rocks certainly seems to point in that direction. Saporta regards the Chalk period as the Golden Age of Sequoia. The best Cretaceous specimens seem to have been obtained in the far north, and are illustrated in the 'Flora fossilis arctica.' Saporta speaks of Pattorfik as a Sequoia wood carpeted with Ferns, and Ekkorfat as a forest composed of Cycads, Sequoias, and Firs. It is quite apparent that in these Arctic forms the distichous and imbricated types of foliage were united in the same species; a character not only preserved in many of the Eocene species, but in the nearly allied Taxodium, and even to some extent in the surviving Sequoias. Heer, through overlooking this

FIG. 15.—*a, b. Sequoia Reichenbachii; c. S. Smithiana.* (Komeschichten, 'Flora foss. arctica,' vol. iii, pl. xxi, fig. 7.)

FIG. 16.—*S. rigida.* (Ibid., pl. xxii, fig. 11*a*).

FIG. 17.—*S. Reichenbachii.* (Ibid., pl. xx, fig. 8.)

character, has been led to make a number of species which cannot be sustained, the pieces so separated being in some cases evidently from the same branch. The truth of this statement is obvious even from the few figures here reproduced. Similar distinctions are made in the forms from the Ataneschichten, named *S. fastigiata, S. subulata,* &c. Another very interesting characteristic, also unmentioned by Heer, is that the distichous arrangement was produced in the Cretaceous species, if the drawings can be

[1] Sir J. Hooker, Lecture to Royal Institution, April 12th, 1878.

trusted, rather by the shortening, almost to abortion, of the upper and under leaves, than through their being narrowed at the base and twisted, as at present, towards the sides of the branchlets.

The Arctic Tertiaries have yielded no foliage of the *S. gigantea* type, except that referred erroneously to *S. Couttsiæ*, which I distinguish as *S. Whymperi*.[1] The *S. sempervirens* type, on the contrary, was exceedingly abundant; *S. Langsdorfii* being, in fact, the prevailing fossil in the Greenland Tertiaries, for scarcely any stones with leaf impressions are without some traces of it. The branchlets seem to have been shed simple or singly, rarely forking, and would thus perhaps appear to have had but a short season of growth, an adaptation possibly to Arctic conditions. *S. Langsdorfii* again appears in the Miocene of the Baltic, in Mull, in the Mayencian or Lower-Miocene stage in Switzerland and Germany, and in Italy in the latest Miocene period. Its course southward from the Arctic Eocenes to Italy, as the temperatures gradually decreased in the Miocenes, is therefore indicated, like that of so many other Coniferæ. The branchlets from the more southern deposits, it is curious to notice, are sometimes compound. Another Spitzbergen species is distinguished by smaller, more tender foliage, and narrower leaflets set at a more acute angle with the stem.

The Eocenes of France have yielded two well-marked species, one very distinctly, and the other to a less degree dimorphic. Another extremely dimorphic form, *S. Hardtii*,[1] is abundant at Steiermarkt and Häring in Austria. *S. Whymperi* seems certainly to have been dimorphic, and to have descended south towards the Miocene. *S. brevifolia* is not dimorphic in Greenland, but becomes so in the American Eocene, and even in the most persistent of the distichous types, *S. Langsdorfii* the fruit-bearing branches are imbricated to a greater extent than is usual in *S. sempervirens* at the present day, though in trees cultivated in warmer climates, as Madeira, the imbricated foliage is relatively much developed.

The purely imbricated type is rare in the Tertiaries. After mature consideration the so-called *S. Sternbergi* of Bournemouth is placed in *Araucaria*, and I have failed to discover any reasons why the greater part of the similar foliage so widely spread in mid-European Eocenes should not also be transferred back to the same genus. In some cases it might belong to Sequoia, but no Sequoia cones have yet been found with it, and until some better evidence is forthcoming it is preferable to consider all the Eocene foliage of this kind as belonging to one genus. In the Iceland Tertiaries, however, there is an unusually large-foliaged *Sequoia*, confounded with *S. Sternbergi*, though it is very distinct in character from the typical form. This reappears in the Superga of Turin, being in both cases associated with cones, and apparently also at Sinigaglia (*Pinites cryptomerioides*, Mass.), and in the Great Lignitic of America (*S. acuminata*, Lesq.).

The striking difference in the form of the foliage belonging respectively to the two recent species is seen to have been far less pronounced in the past; even now *S. sem-*

[1] See *S. Couttsiæ*, p. 39.

[2] Long known as *Chamæcyparites Hardtii*.

pervirens preserves the spiral, scale-like leaves for a longer or shorter distance, according to climate, at the base of each branchlet, while *S. gigantea* sometimes assumes the distichous arrangement. But besides this, the leaflets are not in two rows as they are in Taxodium, for their bases are decurrent and spirally arranged round the stem, becoming a short distance from their attachment twisted to one side, flat, and expanded, and crowded into two lateral rows, apparently in order that their surfaces may be exposed as fully as possible to sun or moisture; and with frequently an additional row lying centrally along the upper surface.

It has been surmised that the genus became well-nigh exterminated during the Glacial Epoch, and has been most strangely preserved in two isolated spots, perhaps outside its original range, where the moderating influence of the Pacific had permitted it to survive upon lofty spurs of mountains, while the valleys were filled with glaciers. Fixed on exceptionally favorable stations and with congenial soil, the existing species may have slowly adapted themselves to a temperature far more genial than that supported by their ancestors.[1] In adapting themselves since the Glacial Period to ever increasingly favorable conditions, they may possibly have acquired that stupendous habit of growth which makes them the giants of vegetation.

Sequoia is thus seen to be a genus which apparently first became differentiated during the Cretaceous, and widely spread and adapted to a great range of climate during the Tertiary, when it contained species which differed greatly from those that have survived. The needle-leaved type is the most ancient, but this became dimorphic during the Cretaceous in high northern latitudes, where it was finally superseded by the distichous type. The latter appears even now to grow more imbricated in warmer temperatures. The former ranged from hot to quite temperate climates during the Tertiaries, but not into such northern countries as Greenland and Spitzbergen.

SEQUOIA COUTTSIÆ, *Heer*. Pl. VI, except fig. 18.

SEQUOIA COUTTSIÆ. Lignite of Bovey-Tracey, Heer and Pengelly, Phil. Trans., 1863.
TAXODIUM DUBIUM. Fossile Flora von Bilin, Ettingshausen, p. 34, pl. x, 1866.
NON S. COUTTSIÆ, *Heer*. Flora fossilis artica, and Miocäne baltische Flora; Baily, 2nd Report on Antrim Flora, British Association Reports, 1880.

Bovey-Tracey, Bournemouth, Hempstead, and Gurnet Bay.

The leaves are alternate, spirally arranged, short and imbricated, keeled exteriorly, concave on the inner surface, decurrent at base, with the apex free and frequently

[1] In estimating the minimum temperature required by the fossil Sequoiæ we may be misled through relying too exclusively on the data furnished by existing species.

acutely pointed, and either divergent or falcate. On the older branchlets the leaves are more obtuse, regularly imbricated, and adpressed, In these and other characters the fossil resembles young shoots of the adult *S. gigantea*, but differs in the smaller size of its foliage. The branchlets, however, seem to be more thickened at the base, and the scars left by them are so distinct that they must have readily become disarticulated. The cones are very different to those of *S. gigantea* (figs. 12 and 18), being shortly ovate and globose,

Fig. 18.—Fertile branch of *S. gigantea*, grown in Linton Park. Natural size. (From Veitch's 'Manual of the Coniferæ.')

averaging apparently but two thirds of an inch in length, but in size, form, number, and arrangement of scales, they approach those of *S. sempervirens* (fig. 11). The chief difference is in the less deeply wrinkled surface and sunk centre of the face of the scale. At Bovey the cones are very much compressed and often distorted, and at Hempstead the

scales are generally detached and scattered. They were doubtless shed, as in existing Sequoias, with the scales gaping after losing the seed, but still attached to the branchlets. Several seeds were stated by Heer to have left their impressions under the scales, and there were probably three to five under each scale, as in *S. sempervirens*. They are variously shaped, ovate, flattened, denticulated at the apex, emarginated at the base, and winged laterally. The best of the cones from Bovey and Hempstead remaining in our national museums are figured on Pl. VI. None of these appear to be exactly those figured by Heer, which, though collected at the same time, appear to have been since lost. The restoration at pl. x, 'Phil. Trans.,' l. c., was pieced together from a number of fragments; and, while delineating the different characteristics of the foliage, can hardly be thought to convey the mode of growth, which was probably free and graceful, dense, and somewhat pendulous. The remains still existing, and which are figured, do not conclusively establish the accuracy of its reference to Sequoia. Its station, from its constant association with remains of a marsh-loving Osmunda, was evidently swampy; and this is at variance with the habits of either existing species.

A large number of remains from the Tertiaries of other countries have been referred to *S. Couttsiæ*. Many of these, however, clearly belong to another species.

The foliage from Disco and from the whole northern regions is, even where smallest, more than double the size of that of *S. Couttsiæ*, while the average terminal branchlets from Bovey require magnifying four or five times to equal those collected by Whymper[1] or those deposited in the British Museum by McClintock. The cones also are considerably larger, exceeding an inch and a quarter in length; and, although making the difference appear less, Heer says, "This greater length certainly arises from the scales having partly separated from their axis," most of the Bovey cones are in a similar condition, and it is difficult, if not impossible, to lengthen those of recent Sequoias, by compression. In Plate VI, I have figured for comparison the largest foliage of *S. Couttsiæ* from Bovey (fig. 7), and the smallest of that called *S. Couttsiæ* from Greenland (fig. 18). The figures in the 'Miocäne baltische Flora,' pl. xiii, also by Heer, are, with one exception, equally large, and the seeds scattered on the slabs with the foliage are two or three times larger than those from Bovey. The supposed *S. Couttsiæ* of Antrim is presumably the same as the Greenland species.

The very beautiful remains from Armissan, which Saporta has figured and described under the name of *S. Couttsiæ*, var. *polymorpha*, possess decided characters which imply more than a variety. Heer determined certain incomplete fragments from this locality as *S. Couttsiæ*, but the fine specimens described by Saporta[2] show that these are widely distinct. At the base of each shoot there is, as in *S. sempervirens*, a region of short, closely imbricated, scale-like leaves; the remaining leaves are long and linear, decurrent at the base, and then free and slightly falcate. This is a growth unknown in the typical *S.*

[1] 'Phil. Trans.,' 1869, pl. xli, figs. 1—9; xlii, fig. 1, p. 464.

[2] 'Le Sud-est de la France à l'époque Tertiaire,' 2nd part, p. 193, pl. ii, fig. 2.

Couttsiæ, and in the Armissan form even the imbricated regions are shorter and more densely clothed than any of the corresponding parts in the Bovey species. The cones figured are smaller and seated upon thicker stems, and their general resemblance does not seem sufficient to outweigh the distinctions seen in the foliage.

It therefore appears that the forms included under the name of *Sequoia Couttsiæ* represent at least two, and possibly three species.

The first, *S. Couttsiæ*, distinguished by the exceptional delicacy of its foliage, which, in this respect, resembles certain species of Cupressus.[1] It ranges in England from the Bournemouth beds, where it is rare, through the Bembridge to the Hempstead series. This species has not hitherto been met with out of England except at Bilin.

The second and more robust northern form, I should propose to name after Mr. Whymper, from whose specimens it was described. *S. Whymperi* approaches more closely to the existing *S. gigantea*, and possessed foliage, cones, and seeds, of approximately double the size of those of *S. Couttsiæ*. It is abundant in the Tertiaries of Greenland, Spitzbergen, the Mackenzie, and Baltic. Some portions of foliage, which seem clearly to belong to it, are separated as *Glyptostrobus Ungeri*. These, while usually associated with Sequoia cones, are never accompanied by any trace of the persistent and very distinct cones of Glyptostrobus, and the infloresence, said to be of Glyptostrobus,[2] is absolutely indistinguishable from that figured as Sequoia in the 'Flora of Bovey,' pl. ix, fig. 43. *S. Whymperi* appears in fact to be another instance, like *S. polymorpha*, of a wide-spread species with so-called dimorphic foliage; and, besides the supposed *Glyptostrobus Ungeri*, I should also feel inclined to unite with it the *S. Langsdorfii* figured in the 'Flora Arctica,' vol. 1, pl. xlvii, fig. 3, and vol. 2, pl. xliv, fig. 2, the *A. Sternbergi* from Oeningen,[3] Sinigaglia, and Turin, and from the newest stage of the Lignitic series of America. It is, and must always be, impossible to describe the extinct Sequoias satisfactorily without first realising that the now nearly completely separated types of foliage were formerly very generally united in the same species; and also that constant and accentuated differences, though perhaps unimportant relative to living trees, when met with and found to be persistent in fossil species, mark clearly either a difference in age between deposits, and therefore a stage in evolution, or else a change in temperature or other physical conditions, and must therefore be recorded and distinguished by the palæontologist.

The third, *Sequoia polymorpha* of Saporta, seems principally confined to the Oligocenes of the south-east of France.

These species may have lived contemporaneously, yet in different regions; the northern form certainly descended as far south in the later Miocene periods as Central Europe.

[1] *C. sempervirens, C. funebris, C. torulosa, C. macrocarpa*, &c.

[2] 'Fl. Arct.,' vol. iv, pl. xi, fig. 8.

[3] 'Fl. Tert. Helv.,' vol. i, pl. xxi, fig. 5.

S. Couttsiæ is rare in the dark clays and "Marine beds" of Bournemouth and the concretionary ledges of Gurnet Bay, but very abundant at Bovey-Tracey and Hempstead.

SEQUOIA TOURNALII, *Brongt.* (sp.). Plate V, figs. 1—12.

TAXITES TOURNALII, *Brngt.* Prodr., pp. 188, 214, 1828.
CHAMÆCYPARITES HARDTII, *Ettingsh.* Flora von Häring, 1855.
SEQUOIA HARDTII, *Heer.* Lignite of Bovey-Tracey, p. 35, 1863.
TOURNALII, *Saporta.* Études sur la Végétation du S.-E. de Fr. à l'Epoque Tert., part 2, p. 196, 1866.

Middle Bagshot, Bournemouth.

The foliage in this species appears to have been distichous on the barren, and closely imbricated on the fertile branchlets. The distichous foliage is like that of the Cupressus from the same locality, but much larger, coarser, more irregular, and of thicker substance. The longest leaflets measure twenty-two millimètres, are nearly parallel-sided, and terminate in a bluntly mucronate point. They are not in opposite pairs, and are irregular in size, an occasional leaflet appearing almost aborted. The specimens show that the distichous foliage did not continue uninterruptedly for any considerable distance, but frequently alternated with the imbricated type, resembling in this respect many existing Coniferæ, and especially *S. sempervirens*. The imbricated shoots figured (Pl. V) seem entire and articulated at the base, and are as large as any yet met with. They are densely clothed with short, closely imbricated leaflets, either falcate or spinous at the apex, and are preserved as deeply and sharply imprinted hollow casts, from which every vestige of colour has disappeared. They present perfect intaglio impressions, which are in some respects more satisfactory than those whose substance is partly preserved, for in these the stem frequently splits in two, and an inaccurate idea of the foliage is thereby conveyed. Fig. 1 shows the arrangement of the branchlets to have been irregular. These, unlike those of the Cupressus of the same beds, were often shed compound.

There is no direct evidence to connect this Conifer with any particular tribe, but it more nearly resembles the living *Sequoia sempervirens* than any other species, and seems indistinguishable from foliage met with at Aix, in Provence, to which well-preserved Sequoia cones are attached. There can be no doubt but that the small imbricated shoot on fig. 3 is actually attached to the branchlet, and fig. 1 also shows imbricated foliage at its base; and this evidence is confirmatory of the view that the two kinds, which are found together, belong to the same species, while Saporta has found far more perfect specimens at Aix (a flora exhibiting the greatest affinity to ours), which exhibit the same combination.

Saporta considers *S. Tournalii* to approach the most nearly of any fossil species to the existing *S. sempervirens*. Short and simple branchlets, appearing naturally detached, are often found at Armissan, covered with the same loosely squamiform leaves, but terminating in short ramifications, or rather peduncles of cones which have been shed. These were in clusters of three to seven, or more rarely singly or in twos, while the cones of the existing Sequoia always occur singly. In the river-deposits of Bournemouth the cones must have been floated away by the moving water and deposited elsewhere, for no trace of them has yet been discovered.

All the specimens figured, except 9 and 12, are from the uppermost "Coastguard-beds." Fig. 12 is from the "Myrica-bed," and fig. 9 from near Poole.

Sequoia Langsdorfii, *Brongn.* (sp.). Plate X, figs. 1, 1 *a*.

Taxites Langsdorfii, *Brong.* Prodr., pp. 108, 208, 1828.
Taxites? Campbellii, *Forbes.* Quart. Journ. Geol. Soc., vol. vii, p. 103, pl. ii, fig. 1 *a*, *b*, 1851.
Sequoia Langsdorfii, *Heer.* Fl. Tert. Helv., vol. i, p. 54, pl. xx, fig. 2; xxi, fig. 4, 1859.

Eocene, Isle of Mull.

The branchlets are irregularly alternate, rather distant, about three centimètres broad and nine centimètres long. The stem of the branch is clothed with very long, distant, scale-like leaflets, closely adpressed for two thirds of their length, and then looser, shortly acute or falciform. The base of each branchlet is clothed for a short distance with somewhat crowded, small, scale-like leaflets; on the rest of the branchlets, the leaflets become for the greater part of their length linear-lanceolate, pointed, rather distant, flat, nearly straight, with a distichous arrangement. The apex of the branchlet is in no case quite preserved, but the termination seems to have been abrupt or truncated, and in a sort of leaf-bud. The expanded portions of the leaflets measure six to nine millimètres in length, and their texture seems to have been leathery and the midrib well defined.

Although the figure of this specimen, described as *Taxites ? Campbellii*, represents small, undeveloped, scale-like decurrent leaflets lying along the stem between the expanded leaflets, none can be now recognised in the specimen. The enlargement shows that every leaflet is fully developed and twisted either to the right or left, every third or fifth having its base in the centre of the stem, and its blade pressed to one side or the other. The pressure during fossilisation has led to the appearance of a secondary growth of undeveloped leaves, and the black and coaly consistence of the fossil has helped to mislead the artist of the plate in question. It is remarkable that all the Coniferæ from Alum Bay and Bournemouth with similar foliage possess the very characteristics attri-

buted in error to the Mull fossil, so much so that this appears one of the readiest means of distinguishing them. (Pls. I, V, VIII.)

Although no fruit of Sequoia has been found in the Isle of Mull Leaf-bed, the characters of the foliage agree in their minute details with those of *Sequoia sempervirens*, though the general form appears to have been more regularly branching. The reference of the species to that genus seems fully justifiable.

There can be little doubt respecting its identity with some of the foliage of the Swiss Tertiaries, attributed to *S. Langsdorfii*, nor with some determined from the Italian Miocene by Massalongho, and the German Miocenes by Weber and Heer. The foliage from the Tertiaries of Greenland and Alaska, undoubtedly belonging to Sequoia, also resembles it very closely, and connects it with a longer and more crowded, distichous, Sequoia foliage from Spitzbergen. Very little of the English, French, or Austrian Eocene Sequoia foliage can be safely united with it, though a branch in the British Museum, from Leoben, in Styria, can in no respect be distinguished from it. Again, *S. brevifolia*, Heer, from the lowest stage of the North-American Tertiary lignites and from Greenland may be but an ordinary variation in foliage, such as can be seen in almost any tree of *S. sempervirens* at the present day. The species, as might be inferred from its almost perfect identity with the living one, had a northern range during the Eocene, Mull apparently having been its southern limit, for, instead of abounding there as in other localities, it is exceedingly rare, and has never been found in Antrim. It seems only to have descended south towards the close of the Tertiary period in company with *Ginkgo*, *Taxodium distichum*, and so many other northern plants which, after traversing Europe during the Miocene or Brown-coal period, finally appear in the newer Miocene of North Italy. Its place was occupied to the south during the Eocene by the dimorphic *S. Tournalii* and *S. Hardtii*, and it is not a little interesting to find that *S. sempervirens* under cultivation at Madeira, in a warmer climate than is natural to it, has, even in the few years since its introduction, taken on a strong tendency towards a dimorphic habit.[1]

Sequoia sempervirens, or the Red-wood tree, is a lofty evergreen, growing from 200 to 300 feet high, and from twenty to thirty feet in circumference, one tree even measuring fifty-five feet in girth, six feet from the ground. It grows abundantly on the mountains of Santa Cruz and the Sierras of primeval California. In the very heart of these immense pine-belts the Red-wood forms, in company with the Sugar-pine, the Douglas spruce, and Incense-cedar, superb columns towering 200 feet, in inviting woods of sunny colonnades and park-like openings.

The original specimen, which illustrated the Duke of Argyle's paper "On the Leaf-Beds of Ardtun Head, in Mull," remains unique, and is in the Museum of Practical Geology at Jermyn Street. I have, however, seen indistinct and scattered leaflets from Uig, in Skye.

[1] The imbricated growth possibly takes place in winter or in spring, and is therefore more prolonged in a warm than in a rigorous climate.

Genus—Athrotaxis.

This is a small genus of three to four species, nearly allied to Sequoia, and inhabiting Van-Diemen's Land. They bear small ovate or globular and woody cones of many scales, of about the size of a hazel nut; and scale-formed, either closely inlaid or open and incurved leaflets. They are small trees, growing near to water, and are tolerably hardy. They are known as Jointed Yews, from their jointed branchlets, and are restricted to a few localities and occur only in limited numbers.

Athrotaxis (?) *subulata*, sp. nov. Pl. XI, except fig. 1.

London Clay, Isle of Sheppey.

The leaflets are spiral in eight rows, thick, scale-formed, closely inlaid, broadly triangular, falcate, keeled on the back, and concave on the inner face. The branchlets fork irregularly, and are from five to ten millimètres in diameter. The cones are solitary on the ends of the branchlets. The only fruiting specimen known is almost globular and measures but little more than ten millimètres in diameter by twelve millimètres in length, and it is composed of over twenty imbricated scales.

Fragments of stems clothed with leaflets are occasionally met with, washed out of the Sheppey cliffs. These resemble branchlets of the existing *Athrotaxis selaginoides*, but the determination rests almost entirely upon a single small cone, which in its form, appears to approach much more nearly to *Athrotaxis* than to any other genus of Coniferæ. Carruthers concurs in the view that with the material no other determination is possible. The foliage also resembles, but more distantly, that of *Dacrydium balansæ*, certain Araucarias, &c.

Tribe III.—TAXEÆ.

The Taxeæ comprise *Taxus*, *Torreya*, *Ginkgo*, *Phyllocladus*, *Dacrydium*, and *Phærosphæra*. They are distinguished by their seeds not being collected into cones, each ovule growing singly and being protected by a fleshy disk, or forming a drupe. The leaves are narrow and veinless, or expanded, with the forked venation of Ferns. They are occasionally large, even gigantic, trees, as *Dacrydium taxifolium*, and occur in the milder climates of both hemispheres, extending on elevated regions across the tropics.

Lindley considered the Taxeæ a more primitive type than the cone-bearing Conifers,

and they can, in fact, be traced with almost certainty to the Carboniferous through ancestral forms of Ginkgo. No other Taxads are known of greater age than the Cretaceous. *Torrelia*[1] of the Tertiary of Alaska possesses long, narrow, leathery leaves, rounded at the end, and with forked venation, conjectured to be coniferous from the base of the leaf being articulated. Distichous twigs have been described frequently from Cretaceous and Tertiary beds as "*Taxites*," but in most instances later discoveries have led to a different interpretation.

There is no conclusive evidence of the presence of Taxus, or the Yew, in any Eocenes, though a few berries are ascribed to it from the Wetterau. It contains about seven species, all hardy, and confined to temperate Europe, Asia, and America. *Taxus baccata* is one of the three Conifers indigenous to Great Britain, and grows in most parts of Europe at heights of from 1000 to 4000 feet. The species generally resemble each other, the most remarkable being *T. Wallichiana* of Northern India, which forms vast forests at elevations of from 8000 to 10,000 feet, and even ascends in Bhotan as a dwarfed form to 11,800 feet.

Torreya has not been found fossil in the Eocenes of temperate Europe. Two species are described by Heer (vol. iii, 'Flor. Arctica') from the Cretaceous of Kome, from foliage and a small detached globose nut; *Taxites microphyllus*, from Alaska, may represent another species. Saporta connects them with *T. nucifera* of China and Japan, through *Taxites validus*, Hr., of the Baltic Miocene. The leaves seem not to have been distichous but in opposite pairs, and their real affinities may still perhaps be doubted. *Torreya nucifera brevifolia* from the Pliocene of Meximieux is, however, scarcely to be distinguished by any character from the Japanese species; and Saporta also believes that a branchlet from Bilin, figured by Ettingshausen as *Sequoia Langsdorfii*, is a representative of *T. taxifolia* of Florida. There now exist but three or four species, all natives of North America, Japan, and China. The fruit is plum-like, containing a single seed enclosed in a hard shell, and the leaves linear and subspiral or distichous. It presents another instance of a Conifer existing in the Arctic Circle during the Eocene, and only spreading over Europe and America towards the later Miocene.

The genus Phyllocladus, or Celery-leaved Pines, contains trees of moderate growth, which are natives of New Zealand, Borneo, and Tasmania. The branchlets are leaf-like and feather-nerved; the leaves themselves are reduced to minute, scale-like bodies on the margins of the branchlets. The only fossil referred to the genus is from the Upper Cretaceous of Spitzbergen, but even this possesses hardly the most slender character connecting it with Phyllocladus. Phærosphæra, a genus with small scale-like foliage and solitary fleshy fruit, contains but a single species from Tasmania. Dacrydium contains some ten species, natives of the Malays, Fiji, New Caledonia, New Zealand, Tasmania, and Chili. One, *D. cupressinum*, is said to reach 200 feet in height, and *D. elatum* and *D. Franklinii* are also very lofty trees, while, on the other hand, *D. laxifolium*

[1] Heer; not to be confounded with the existing *Torreya*.

barely attains three feet when full grown. The fruits somewhat resemble those of Podocarp. No fossil has been referred to it, though some fossil foliage bears a great resemblance to it. GINKGO is the only genus that has been recorded from the British Eocenes.

Genus—GINKGO.

The genus, better known as *Salisburia*, possesses a single species. Its leaves are adiantoid, leathery, very variably lobed, and of all sizes up to an extreme of five inches across, and deciduous. The fruit, about an inch in diameter, is drupaceous, on a slender foot-stalk, composed externally of a fleshy layer, and internally of a hard light-coloured shell, somewhat unsymmetrical owing to the abortion of one of the seeds. The foliage, though like that of the maidenhair fern, may when fossil be recognised by its stout petiole, often three inches long and distinctly articulated at the base. Again, however irregularly the leaf may be lobed, its primary bilobation is discernible.

Though so singularly restricted a genus now, its ancestry is perhaps more venerable than that of any other forest tree. The Carboniferous fruits, *Trigonocarpum* and *Noeggerathia*, are believed by both Hooker and Saporta to have belonged to some allied form. *Psygmophyllum* of Schimper approaches nearly to Ginkgo, and even true Ginkgo has been said to be found in the Carboniferous. *Baieria*, beyond doubt a close ally, appears in the Permian, and the bilobate *Jeanpaulia* of the Rhætic of Bayreuth is probably a true Ginkgo; but an even more definite species has been found in the same system in Australia. The group, however, did not reach its maximum development until the Jurassic period. Heer's 'Jurassic Flora of Eastern Siberia'[1] contains a most important contribution to their past history. Five genera are placed in the group:—*Ginkgo*, *Baieria*, *Trichopitys*, *Phœnicopsis*, and *Czekanowskia*, the two latter of which seem, however, to have little affinity with Ginkgo. The most aberrant form, obviously belonging to the group, is *Trichopitys* of Saporta, in which the parenchyma is reduced to a narrow expansion bordering the veins, yet with the characteristic bilobation and petiole preserved. Its affinity is best traced through *G. concinna*, which is similar, but the segments of the leaves are more expanded and receive two or three veins each.

The Arctic Ginkgos have been subdivided by Heer into too many species: the leaves of the existing species are so excessively variable under different conditions of growth that their varieties would more than embrace all the supposed Jurassic species. The second genus, *Baieria*, possesses a larger and more palm-like leaf averaging nearly five inches in radius, its bilobation and venation connecting it closely with Ginkgo. The persistence, throughout the whole group, of characters which would hardly have been suspected to possess a morphologic value is a peculiarly interesting fact.

[1] 'Flor. Foss. Arctica,' vol. iv.

There is a marked diminution in the group in the Cretaceous. Baieria from the Komeschichten is limited to vestiges, of stunted form, described as Ferns, while Ginkgo appears in a starved species with small leaves and short thick petiole, described as *Adiantum formosum*, and by fragments from the Ataneschichten, inappropriately named *G. primordialis*. In the Arctic Tertiaries, Ginkgo is met with sparingly in Greenland only, where it so much resembles *G. adiantoides* of the Italian Miocenes that Heer almost directly abandoned his specific name *primordialis*, and became doubtful even whether both should not be united with the existing species. Coming south there are small and doubtful fragments from the Baltic Miocene, and it is only again met with in the later Miocenes and Pliocenes of Italy and the South of France. It is completely unknown in either the Eocene or Oligocene in temperate Europe, with the one exception of Ettingshausen's *Salisburia eocœnica* of Sheppey, about which there is some room for doubt.

GINKGO (?) EOCÆNICA, Ett. and Gard. Plate IX, figs. 31—34.

SALISBURIA EOCÆNICA, *E. and G.* Proceed. Roy. Soc., vol. xxix, p. 392, 1879.

London Clay, Sheppey.

The fruits or seeds are entirely pyritized, irregularly ovate, and variable in form. The largest measure some eleven millimètres in height by about nine millimètres in breadth, but they are occasionally wider than high, and more or less compressed, varying from seven to barely four millimètres in thickness. They are sharply keeled, the keel is sinuous and the seeds consequently not symmetrical. There is a small truncated projection at one extremity, greatly resembling that seen in the existing seed of Ginkgo, but at the other end of the seed there appears a trace apparently of a scar of attachment.

They are perfectly smooth, and are probably interior casts of the shell filled with amorphous pyrites. They are much smaller and more sharply keeled than in Ginkgo, which they otherwise resemble in general form; but if the slight scar which they present is truly one of attachment, it would point to a leguminous origin. A great variability in the form of the seed is also seen in the existing species. Several of these seeds are preserved in the Bowerbank Collection in the British Museum. They are now difficult to obtain, being either very rare or overlooked by collectors at Sheppey.

FIG. 19.—Seed of *Ginkgo biloba.*

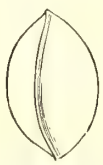

FIG. 20.—Edge view of same.

The sole existing representative of the genus is the gigantic *G. biloba*, apparently indigenous to Northern China, for it is only met with in the immediate vicinity of

temples and is unknown in a wild state, the aboriginal stock having possibly become extinct.[1]

Imported into England about 1754, it thence found its way to the Continent, and now flourishes and bears fruit abundantly in Padua, Avignon, Montpellier, &c., and has even been known (1853) to fruit at Versailles. It is sterile at Geneva and almost everywhere to the north, and the isotherm best fitted to it would therefore seem that of the Corea or even a little to the north of that point. It requires a considerable summer heat.

Although fossil species of the Jurassic period have been met with so far south as Yorkshire, it appears to have been an essentially northern genus, for it disappears from temperate Europe thenceforward with slight exception until the Pliocene age. It is everywhere unknown, except from polar regions, during the older Tertiaries; a supposed species from the Missisippi having proved to be a fragment of *Lygodium*, and it therefore seems somewhat unlikely that the high temperature in which vegetation flourished late in the London-Clay time would have been favorable to its growth. The doubt which must exist, in the absence of any foliage of the genus in other Eocene deposits, whether the resemblance which these seeds bear to Ginkgo may not be accidental, is at least shared by Saporta.

Tribe IV.—PODOCARPEÆ.

The tribe contains, according to the *Genera plantarum*, but three genera. Two of these, Microcachrys, a small shrub confined to Tasmania, and Saxe-Gothea, a larger bush confined to the mountains of Patagonia, are each represented by a single existing species, nothing yet being known of their ancestry. The seeds in both are contained in small fleshy cones. The third genus, Podocarpus, is widely distributed throughout the Eocenes of Southern Europe.

Genus—Podocarpus.

The flowers are diœcious or rarely monœcious; the fruit is either drupaceous or nut-like, and inverted; the seeds are hard, with a crustaceous integument; the leaves coriaceous, and either opposite, alternate, or scattered, linear or oblong, with a single median nerve, or more rarely with a dicotyledonous venation. The genus contains fifty-nine species, according to Gordon, many of which, however, are so little known that Hooker and Bentham believe them capable of reduction to forty. These are divided into four sections:—*Nageia*, with opposite or alternate many-veined leaves and round

[1] Masters, 'Linn. Soc. Journal,' vol. viii, p. 481, "On the Coniferæ of Japan."

drupaceous fruit, comprising according to Gordon, eight species which inhabit from New Caledonia to Japan, one being the only Conifer indigenous to Hindustan. *Eupodocarpus*, in which the leaves are linear, with one nerve, and the fruit solitary, with a fleshy receptacle, comprising forty-six species according to Gordon. *Stachycarpus*, with linear single-nerved leaves, alternate or in two rows, and fruits born on spikes without the fleshy receptacle, possessing but two species. *Dacrycarpus*, with squamiform spiral leaves on the fertile branches, flat and distichous leaves on the barren, and fruit similar to, but smaller than in Eupodocarpus, comprising four species.

The Podocarps vary from mere shrubs to colossal trees, and are widely spread over the Southern Hemisphere. They are well represented in the Oriental, Ethiopian, Australian, Neotropical, Palæarctic, and China—Japan provinces; and in the Nearctic province by a single Californian species.

Notwithstanding this almost world-wide distribution, and the evidence of antiquity which the genus presents, scarcely anything is known of their past history. In most cases the foliage when detached has little to distinguish it from that of better known Coniferæ, and the fruits, in the fossil condition, seldom present anything by which their Gymnospermous nature can be detected. Except a doubtful and undescribed species from Aix-la-Chapelle, no Podocarp is known of earlier age than Eocene, when they at once appear with a wide distribution over temperate Europe, again as suddenly disappearing with the Oligocene. No Podocarp has been made known from either the Arctic or the American Cretaceous or Tertiary series, and therefore, either the distribution of existing species must have been accomplished prior to the Cretaceous period, or, in order to explain their presence in Chili and other parts of South America, we are forced to admit a land connection far to the south of that relied upon by Wallace and those who share his opinions.

FIG. 21.—Fruit of *Podocarpus elata.*

FIG. 22.—Apex of the same.

The fossil Podocarps that are only known from their foliage may be conveniently classified under two heads, those that have shed their leaves separately, and those in which they remain adhering to branchlets. Both sections are represented in our British Eocenes.

PODOCARPUS EOCÆNICA, Unger. Plate II, fig. 6—15.

UNGER. Fossile Flora von Sotzka, p. 28, pl. ii, figs. 11—16, 1850.
— Sylloge Plantarum Fossilium, pl. 31, pp. 10—12, 1860, &c.

Middle Bagshot, Bournemouth; Lower Bagshot, Alum Bay; Upper Bagshot, Hordwell; Middle Eocene (?), Mull, and Antrim.

The Bournemouth specimens are linear-lanceolate, the margins being parallel for nearly the entire length; the apex is acute and the base broadened and sessile. No venation is discernible except the midrib, which shows more strongly on the back of the leaf than on the face. Their condition of preservation betrays a very coriaceous consistence. Figs. 9 and 10, both representing imperfect leaves, exhibit a total length of over three inches, with a breadth of only three-sixteenths of an inch, but these may possibly be neither the same species as the other leaves, nor even Coniferous. A fine and perfect typical example of true Podocarpus is delineated in fig. 7. The length of the leaf is seven millimètres, the breadth barely three millimètres; the apex is sharply pointed and mucronate, the base sessile, about one millimètre broad; the midrib strong and distinct, and the colour a deep brown. The leaves from Mull are identical with it in every respect, save colour, and apparently also a half leaf from Antrim. This is the more remarkable since at Bournemouth the species is strictly confined to the Uppermost "Coastguard Bed," and has never been met with in any of the other numerous beds, from which large collections have been made. The remaining specimens from Bournemouth agree well with it, except fig. 8, which is a much smaller leaf, becoming broader towards the apex, with a slender, petiolated base, and thin and sharply defined midrib. Our species differs materially in its broadly sessile and articulated base, and narrow linear form with parallel margins, from all the many similar Podocarp leaves described from the Continental Eocenes. It bears the greatest resemblance to *P. gracilis*, Sap., from Aix, and *P. Peyriacensis*, Sap., from Peyriac, yet differs from these in the sessile base and mucronated apex.

The single leaf known from Alum Bay (fig. 15) has a different character, tapering to an apparently petiolated base and a pointed, but not mucronated, apex. This measures seven centimètres in length and six millimètres in breadth; and while agreeing closely with *P. plana*, Wat., *P. proxima*, Sap., and *P. eocænica*, Ung., differs very markedly from the Bournemouth type. No venation is discernible, except the strongly marked midrib, and the leaf was obviously coriaceous. Figs. 13 and 14 represent much smaller, and also very coriaceous, leaves from Hordwell, which, if referable to Podocarpus, would probably belong to another species.

Unger,[1] who first described them, explains the microscopic leaf-structure of Podocarpus in great detail, as well as that of the wood, which he also met with fossil. More than a dozen extinct species have been made from the Tertiary leaves of this type, and though Heer has united several, such as *P. mucronulata*, Ett., *P. hæringiana*, Ett., and *P. taxites*, Ung., about eight species remain. Some of these can perhaps scarcely be regarded as satisfactory; and it does not appear, in the present state of our knowledge, that any useful purpose can be served by adding further to them. The broad fact is of

[1] 'Sylloge plantarum fossilium,' pl. 31, pp. 10—12. The specimens were from the Wetterau. He considered the arrangement of stomata, which he represents magnified 100 and 360 diameters, to be most like that existing in *P. nubigæna* of Chili.

great interest that Podocarps with foliage very similar to such forms as *P. andina*, *P. chilina*, *P. elongata*, *P. falcata*, *P. novæcaledoniæ*, and others belonging to the Eupodocarpous or Stachycarpous divisions, were widely spread over Europe during at least the Middle-Eocene period. They range in time from the Suessonian to the lowest stage of the Aquitanian, and thus form a group essentially characteristic of the Eocene in Central Europe. They seem soon after to have migrated, for, except in Italy, they are totally unknown in the Miocene. The chief localities in which they have hitherto been met with are Sotzka, Häring, Bilin, Ralligen, the oldest Tertiary plant-bearing formations in Switzerland, the Grès du Soissonais, Grès de la Sarthe, Aix, Armissan and Peyriac in France, Koumi in Eubœa, Bournemouth, Alum Bay, &c.

They are thus known to have occurred in Western Europe during the Eocene, from Aix, lat. 43° to about lat. 48°. Their presence, therefore, so much farther north in Antrim and in Mull, lat. 56·30°, emphasises the importance of the results to be expected from a careful examination of our British Eocene Floras.

Although no fruits belonging to this species have been recorded, and it would be difficult to find any essential characters by which to recognise them when detached, the leaves, which appear undoubtedly Coniferous, could from their size belong to no other genera. The only other genera with at all similar foliage, are Cephalotaxus, Taxus, and Torreya.

The number and great range of the existing species with similar foliage, and the varied temperatures which these different species sustain, render it unlikely that they will afford safe data for estimating past temperatures, but from their somewhat limited vertical range in time and changing forms, they may, with other plants, become valuable data in ascertaining the relative ages of Tertiary plant-beds in Europe.

Podocarpus elegans, De-la-Harpe (sp.). Plate VIII, figs. 1—16.

Cupressites elegans, *De-la-Harpe*. Mem. Geol. Survey, Isle of Wight, p. 111, pl. v figs. 1—3, 1862.

Glyptostrobus europæus, Sequoia Langsdorfii, S. Couttsiæ, *Ettingshausen*. Fossil Flora of Alum Bay, Proceed. Royal Society, vol. xxx, p. 231, 1880.

Lower Bagshot, Alum Bay.

The leaflets are opposite, narrow, linear, spreading, and in two rows; or three-sided, awl-shaped, and acute, and in five rows; their size varying in the first form from very small to almost twelve millimètres in length, and two millimètres in breadth. They are coriaceous, finely parallel-veined, with inconspicuous midrib, and a surface irregularly dotted with pits just visible without a lens; and they either taper to a point or are

bluntly rounded. The angle formed by the leaflets, which are often crowded and overlap, averages about 20°, and their bases, as in many recent Conifers, are decurrent on the stem until overlapped by the succeeding leaflet. The basis of their arrangement seems spiral, though only the lateral leaflets are expanded, the rest being narrow and closely pressed to the branchlets. In the smaller terminal shoots they are less in size, more tapered and acute, and therefore to a slight extent intermediate between the expanded and the imbricated foliage. This latter is loosely imbricated, spinous, recurved, or falcate, often approaching the distichous type.

An example of what is apparently the fruit of the species is shown in fig, 16; in which case it must have been a small solitary berry on a short pendant stalk, as in *P. andina* and some other Podocarps, and not terminal. Though rather crushed, the characteristic footstalk seems to ally it to the section Dacrycarpus.

Although by no means closely related to any known existing species, the specimens recall *P. cupressina*, of Java and the Philippine Isles; particularly fig. 11, which agrees most closely with it in the relative positions of the broad and scale-leaved shoots. It also resembles *P. tenuifolia* of New Caledonia, and other species, and the foliage bears a general resemblance to that of Taxodium, but is more coriaceous.

While there can be no reasonable doubt about most of the figured specimens belonging to one species, some of them may belong to quite other Conifers,[1] though they do not afford characters which enable them to be definitely separated. None of the foliage has been met with except at Alum Bay, and it differs from any of the similar kinds of foliage from Bournemouth; yet it is difficult to formulate any well-marked distinctions, which would allow of isolated pieces being immediately recognised, when met with elsewhere. The richer parts of the Alum Bay leaf-beds have now been washed away; and the two specimens with fruit were almost the last fossils obtained from it.

The only fossil resembling it is *P. taxiformis*, Sap., from Armissan.

De-la-Harpe[2] mentioned the occurrence of branches of Coniferæ at Alum Bay, resembling *Cupressites taxiformis*, Ung., and *Taxites Rosthorni*, Ung. They were described at greater length in the 'Memoirs of the Geological Survey, Isle of Wight,' 1862, p. 111, by the same author, as *Taxites*, sp., and *Cupressites elegans*, De-la-H. The separation is made on slender characters, and the latter type is compared to *Dacrydium cupressifolium*.[3]

[1] A large drupe, since discovered, seems to indicate a second Podocarpous species.

[2] 'Bull. Soc. Vaudoise des Sc. Nat.,' 1856.

[3] Ettingshausen, in his "Report on the Fossil Flora of Alum Bay to the Royal Society" ('Proceed. Roy. Soc.,' 1880) introduced six species of Coniferæ into his list, three of which were founded on material now figured in the accompanying plate, two others on fragments which seem to be of a doubtful coniferous character, while the sixth has been here mentioned, p. 49, under *Podocarpus eocænica*.

PODOCARPUS ARGILLÆ-LONDINENSIS, sp. nov. Pl. IX, figs. 35 and 36.

London Clay, Sheppey.

Fruit compressed, globose, nearly as long (sixteen millimètres) as wide (fifteen millimètres), deeply and finely wrinkled; apex small, not central, slightly produced and recurved; basal-scar a small pit, subcentral, and inclining to the same side as the apex. The external wrinkled coat of the fossil represents the desiccated integument, while the next layer, probably the bony shell of the seed, is somewhat rough and pitted, and the nut, visible inside, is smooth.

This fruit very strikingly resembles that of *P. elata* of Queensland, (fig. 21, 22, p. 48) the determination resting entirely, in fact, upon the exceedingly strong likeness which the two bear to each other. It is very rare at Sheppey, the specimen sent to me by Mr. Shrubsole, F.G.S., being unique.

PODOCARPUS (?) INCERTA, sp. nov. Pl. II, figs. 1—5.

Middle Bagshot, Bournemouth.

Foliage distichous, opposite, or alternate; leaflets long, linear-lanceolate, bluntly pointed, parallel-sided, constricted at the base, and thence decurrent on the stem, the largest measuring three centimètres in length by five millimètres in breadth, with five parallel veins and inconspicuous midrib. As in many other Coniferæ the leaflets are occasionally abortive, and in addition to those expanded in two rows the stems are clothed with narrow, decurrent, scale-like leaflets. In texture and venation the leaflets somewhat resemble those of Cycads, but their arrangement shows the species to be undoubtedly coniferous. The foliage is more like that of some of the Podocarps than of any other species of existing genera, but it possesses no character which would altogether preclude its reference to other Tribes of the Coniferæ.

It is the largest of all the Yew-like Eocene foliage, and is easily distinguishable by its fine parallel venation, with an absence of midrib, smooth or glossy surface, and blunt terminations. It is confined to the "Gleichenia-beds" at Bournemouth, where it is relatively rare.

TRIBE V.—ARAUCARIEÆ.

The genera recognised in Bentham and Hooker's 'Genera Plantarum' are *Cunninghamia*, *Agathis*, *Araucaria*, and *Sciadopitys*. They are distinguished by their cones, composed of exceedingly numerous spirally imbricated scales, and wingless or marginally-

winged seeds. The two principle genera are entirely confined to the Southern Hemisphere; the others have each a single species, and are natives the one of Japan and the other of China.

The earliest traces of distinctly Gymnospermous wood were for years supposed to present the Araucarian structure. The foliation of the Permian genus *Walchia* and the Triassic *Voltzia* resembles that of *Araucaria*, but the latter possesses an abnormal cone, consisting apparently of altered and expanded leaves, a peculiarity which is even more striking in the allied *Glyptolepis*. Another protean genus, *Palissya*, seems to approach *Cunninghamia*. These remote genera are probably, however, extinct types, ancestral perhaps to several existing tribes of the Coniferæ. The first distinctly Araucarian genus *Pachyphyllum* is met with in the Lias, and believed by Saporta to combine characters of *Agathis*, *Cunninghamia*, and *Araucaria*. In the Stonesfield, Somersetshire, and Yorkshire Oolites, cones with every character of true *Araucaria* make their appearance,[1] and have been described by Carruthers; and from Solenhofen by Th. Dyer; while forms agreeing closely with these have also been found in the Jurassic rocks of India. It is not yet known from Cretaceous rocks, for the larger fossil cone figured by Heer as *Araucarites Nordenskiöldi*, from the Upper Cretaceous of Spitzbergen, is a very indistinct coaly mass, and, as he suggests, probably Cycadaceous.[2]

Small Araucaria-like foliage, both of the imbricated and needle-leaved types, is very abundant in the Cretaceous series of Aix-la-Chapelle, and is also met with in several localities on the same horizon in France. It appears probable, from the constant association of the two types of foliage together in so many places, that they may have belonged to the same plant.

Of the other existing genera, Cunninghamia, a native of China, has been described from German Cretaceous rocks as *Cunninghamites*, and a fragment has even been determined from the Miocene. No fossil representative of the Japanese Sciadopitys is known, except from the Amber-beds of Samland, in Prussia.

Genus—Agathis.

The flowers are monœcious or diœcious, cones globose, scales numerous and persistent, the seeds unattached, solitary, or rarely in twos, and occasionally winged on one or both margins; leaves sub-opposite, ovately oblong or rarely lanceolate, leathery, and finely parallel-veined.

[1] Lesquereux believes that cones of true *Araucaria* occur in America as far back as the Trias.

[2] 'Flora foss. Arctica,' vol. iii, pl. xxxvii, p. 126. Heer acknowledges the figure to be much too distinct, and that the position and arrangement of the scales can only be made out with the greatest trouble. Restored as it is, it possesses no distinctly Araucarian characters, and while no branches of Araucaria are found Cycadaceous foliage abounds in most Cretaceous rocks in high latitudes.

The existing species, eight to ten in number, better known by the name of Dammara, are natives of Australia, New Zealand, the Malayan and Fiji Isles, New Caledonia, and New Hebrides. The best known species are the Amboyna and the Kauri Pine, both trees exceeding 100 and even 180 feet in height. The latter is the most beautiful and celebrated of all the New Zealand Conifers, and except Athrotaxis, the only one bearing cones. Its range is limited to the long and slender North-Western peninsula of the North Island. The range of the tree depends upon the moist sea breeze and stiff clay soil which are there united, for the Kauri loves to be near the sea, and the richest forests and most luxuriant timber are found along the shores of Kaipara Harbour and its affluents upon the coast of the peninsula. It grows in groups of trees of approximately the same age, and thus clumps of 100, 200, 400, or 500 year[1] old trees are met with. Extensive districts formerly covered with the Kauri Pine are now destitute of them, and half-decayed giant stems and the gum which the natives dig are, according to Hochstetter,[2] the only indications of the former extension of the woods over many large and barren tracts. Its final extinction is feared to be as certain, and will probably be accomplished as speedily, as that of the Natives of New Zealand.

Two cones from the Cretaceous have been described as *Dammarites*, which Schimper believes, however, may be Cycadeous.

There is slender evidence suggesting that an *Agathis* near to *A. robusta* of Queensland, or to some of the Malayan species, formed part of the Bournemouth Eocene Flora. The leaf figured (Pl. II, fig. 16) seems to have possessed the peculiar leathery texture and silky face, with the very fine parallel venation, and twist at the base, characteristic of Agathis, and fig. 21 represents a scale in no way dissimilar to a detached scale from the cone of the same species. Saporta also is now convinced that an Agathis with the foliage of *Araucaria Cunninghami* existed side by side with species of Abies down to a very late Miocene period.

Genus—Araucaria.

The Araucarias are dicœcious, the pollen- and the ovule-bearing catkins being produced on different trees, or rarely moncœcious. The cones are globular, terminal, and erect, with very numerous scales disposed in spiral rows, and more or less deciduous. The seed-scales and the bract-scales are firmly soldered together, the combined scale presenting a distinct double apex. The seeds are large, firmly adherent, and more or less laterally winged. The leaves are coriaceous, spirally disposed, and persistent for many years. In the division *Columbea* they are broad and scale like, and in *Eutassa* lanceolate and acute.

The Araucarias are lofty evergreen trees, natives of the Southern Hemisphere, with

[1] Individuals are supposed to reach an age of 700 or 800 years.

[2] 'New Zealand,' Hochstetter, English edition, 1867, p. 143.

perfectly erect trunks and horizontal or decumbent branches in whorls. They present a singular and unmistakably archaic appearance, and are divided into two distinct sections: Columbea, or true, and Eutassa, or false, Araucarias. The former comprises four species, all of great dimensions, the most familiar being the *Arauc. imbricata* of Chili, where it forms vast forests, extending on the Andes from the snow-level, 1500 or 2000 feet downwards. A second American species is confined to Brazil, a third to a tract thirty miles long and only twelve miles broad, near Brisbane in Australia, and the fourth is only indigenous to Porte Molle, one of the Caledonian Isles, where it is confined to the summit of an extinct volcano, only half a mile in radius. The Columbeas have not been met with fossil, either in the Eocene or Cretaceous rocks, except from New Zealand, where two species are known from Cretaceous coal-bearing beds, and have been figured by Dr. Hector, though yet undescribed. The rarity of their preservation is not surprising, because their stations are mostly high rocky ridges, where there is an absence of water, rendering it unlikely that their remains would find their way into marine or fluviatile sedimentary strata. It would be unsafe, therefore, to infer that species belonging to this section did not exist in Europe contemporaneously with the species of Eutassa that have been found.

The Eutassas possess but three known existing species, all of gigantic size. One, a native of New Caledonia and New Hebrides, presents a fantastic columnar-like growth, over 200 feet in height; another, *Arauc. excelsa*, is indigenous to Australia and Norfolk Island, and towers to a height of 230 feet, with a trunk thirty feet in girth. The third grows in Australia, and is referred to in the description of the fossil species. All the species, it is very important to notice, are polymorphous, and the foliage when young differs considerably from that of adult trees.

Schimper states that with the Tertiaries the Araucarias became extinct in Europe, and Thiselton Dyer even believed them to have been extinct north of the Equator since the Oolitic age.[1] They seem, however, to have remained until the close of the Eocene.

ARAUCARIA GOEPPERTI, *Sternb.* (sp.). Pl. XI, fig. 1; and Pl. XII.

ARAUCARITES GOEPPERTI, *Sternberg*. Verst., vol. ii, p. 204, pl. 39, fig. 4, 1821—1838.

STEINHAUERA SUBGLOBOSA, *Presl*. In Sternb., Flora der Vorwelt, vol. ii, p. 202, pl. xlix, &c., 1821—1838.

ARAUCARITES STERNBERGI, *Goepp*. In Bronn, Geschichte d. Natur., vol. iii, p. 41, and also of numerous authors, 1841—1849.

SEQUOIA STERNBERGI, *Heer*. Urw. d. Schweiz., p. 310, 1864, and later works.

ARAUCARIA VENETA, *Mass*. Spec. Photogr., p. 69, pl. xxi, 1859.

[1] 'Roy. Geog. Soc. Proceedings,' 1878, vol. xxii, p. 427.

Non. S. Sternbergi, Heer, 'Flor. Tert. Helv.,' vol. i, p. 35, pl. xxi, fig. 5; vol. iii, pl. 2, figs. 1—4; pl. vii, figs. 3—5; 'Flor. foss. Arct.,' vol. i, pl. xxiv, figs. 7—9; vol. iii, pl. 2, figs. 1—4; A. Sternbergi, Mass., 'Flor. Senigal.,' p. 154, pls. 5—7, 40; Sismonda, 'Mem. Reale Accad. di Torino,' 1865, p. 404, pl. iv, fig. 6!

Upper part of Freshwater beds and Marine beds at Bournemouth.

Only foliage has yet been met with in England. The leaflets are moderately short, falcate, and awl-like, quadrangular in section, thickened at the base, and with the lower side produced and decurrent on the stem, disposed spirally round the branchlets, which they quit at first at a right angle and then curve gently upward and inward, free or in slight contact at the apex with the row above. The branchlets, eighteen to twenty inches in length, are usually simple for five or six inches, and then fork copiously and chiefly horizontally. They are articulated at the base, and when broken away a lozenge-shaped scar remains, internally hard and ligneous, the woody core penetrating the smallest forks, while the leaves spring from the external cortical system. The specimens either taper and end in a leafy rosette or are constricted and swell into an oval bud. Branchlets resembling these in the minutest particulars, articulated at the base, and representing one year's growth, are annually shed by *Araucaria Cunninghami,* and are doubtless buried at the present time on the muddy shores of the Brisbane River, very many miles away.

In *A. Cunninghami* the tough woody core of the branch penetrates half way into the cone, when it gradually becomes spongy and vascular, and is lost towards the termination in a pulpy mass. This is surrounded by a somewhat pulpy layer, a quarter of an inch in thickness, a continuation of the fleshy bark from which the leaves spring. Upon this the scales are arranged spirally and at nearly right angles. When immature they are socketed into depressed scars on the axis, but, as the cone ripens, the attachment ceases by desiccation, and the scales, to which the seeds are firmly soldered, become held only by a single woody fibre which, parting from the central woody core of the axis, penetrates the scale. When ripe and shaken by wind, the whole of the scales fall away at once, except a few barren ones towards the base. The branchlets fall chiefly, I believe, in the spring, long after the seeds have been shed. My friend, Leland C. Cossart, of Madeira, has, moreover, ascertained for me that foliage of *Araucaria Cunninghami* requires two or three days to sink; while of the mature seeds of a cone, none sank before five to six days, and at the end of ten days there were still about 15 per cent. at the surface, so that in moving water they would therefore necessarily be deposited separately. The axis of the cone remains on the tree, for cones are never produced on the annual articulated branchlets, but only on the persistent branches. Indeed, it appears that each compound scale of the cone is an altered deciduous branchlet and not, as in the Abietineæ, merely an altered leaf. Only in cases where some violence has operated could a young cone, with the sap still flowing, and therefore in a condition to hold together, become detached. These facts explain the absence of any trace of cones among the very large quantity of

[1] 'Verst.,' vol. ii, p. 204, pl. 39, fig. 4.

foliage met with at Bournemouth, and go far to support its determination. Such an abundance of foliage with a total absence of cones or seeds in a marine deposit is extremely rare.

The foliage is met with, hardly less abundantly, in many other Eocene localities in Europe, and in some of these fossil cones are not so absolutely unknown. One was figured by Sternberg[1] from Häring, completely covered with bracteated scales, as shown in the annexed figures of immature cones of *A. imbricata*, kindly lent me by Messrs. Veitch, and was considered to be, and described as, the cone of an *Araucaria*, comparable with *A. imbricata*. It was some years later refigured by Göppert, who believed the cone to belong to the foliage which he then described as *Araucarites Sternbergi*.[1] A second

Fig. 23.—Immature male and female cones of *A. imbricata*.—From Veitch's 'Manual of the Coniferæ.'

cone was found at Chiavon and figured, together with foliage, by Massalongho [2] as an Araucarites. It was forty-five millimètres long and twenty-seven millimètres wide, with transversely rhomboidal scales, provided with triangulated, unciniform, recurved umbones. Though the photograph is not very distinct, 125 scales can be counted on the exposed half, so that the cone must have been composed of at least 250. None of these botanists, or others, ever doubted that these represented young and immature cones of *Araucaria*; but notwithstanding their structure Heer transferred them to *Sequoia*,[3] and in the

[1] 'Haarlem Trans.,' 1850, pl. 44, fig. 2, p. 237.

[2] Specim. Photogr., pl. xxi.

[3] Heer seems to have compared it with a different type from Iceland and the Miocene of Turin, with which Sequoia cones are associated, and hence, I believe, changed Sternberg's name.

'Flora of Bovey, p. 35, stated his opinion that Massalongho's cone is quite different from *Araucaria* and very like *Sequoia gigantea*, though the cone of the latter is formed of at most thirty to thirty-five scales of a perfectly different form (see fig. 12, p. 33). Ettingshausen has recently obtained a second cone from Häring which is much compressed and imperfect, but the form is seen to be globular and composed of very numerous scales which resemble in form those of *A. Cunninghami*. There can be little doubt but that all these are immature cones of *Araucaria*, accidentally severed in some manner from the tree.

Foliage identical with ours is found very abundantly at Chiavon, Sotzka, and apparently at Monte Colle and Monte Promina. In that from Häring the leaves seem a little less dense and slightly less curved. All these are placed in the lowest stage of the Miocene by Heer, but are usually considered to belong to the Upper Eocene or Oligocene. A much smaller and different form is figured under the name from Bilin, where it is rare, and another from the Miocene of Greenland; these, however, more nearly agree with quite another Conifer to be described from Mull and from Canna. None of the other references of specimens to this species appear to me to be correct.

The foliage is distinguishable from that of existing Eutassas, except *A. Cunninghami*, for in these the articulated adult branchlets are simple and the leaves broader and more imbricated. The only other Coniferæ which resemble it are *Cryptomeria japonica*, in which the leaves are much longer, straighter, and quit the stem at an angle of about thirty-five degrees, with very numerous and persistent cones; *Athrotaxis selaginoides* and *Dacrydium araucarioides*, in which the leaves are more imbricated, and *Sequoia gigantea*. It is, however, only the immature foliage of young plants of the latter which resembles it; and then the leaves are longer in proportion, less regularly disposed and less curved, and quit the stem at very acute angles, and therefore with their points irregularly overlapping the succeeding row. The cones of *Sequoia* are in addition small, composed of few scales, and so persistent on the branches that they are almost always found associated with the foliage.

The distribution of this Araucaria at Bournemouth is very clearly defined, and shows plainly that its habits, when growing in our latitude, did not differ from those it now possesses. No trace of it is met with west of the Pier, in the beds whose floras may be thought, from their characters, to have come from districts farther from the sea; but east of the Pier it abounds everywhere in company with Fan Palms, Eucalyptus, Aroids, Ferns, &c., and in certain beds of sandy mud of the "Marine series," the branchlets are heaped together in perfect preservation and cross each other in every direction.

The existing *Araucaria Cunninghami* forms vast forests on the shores of Moreton Bay, on the alluvial banks of the Brisbane River, and grows in the greatest profusion in the bush forests of the Richmond River. "The trees seem to thrive best near the coast, attaining in such a situation their greatest height, often from 100 to 130 feet, but gradually diminishing in height the farther the trees are inland. It would appear from

this that the sea air has a great effect on it."[1] These bush forests are thus described by Moore:—"The bush is characterised by denseness of growth, the altitude, and beautiful dark green foliage of the trees, the presence of lofty climbing plants, which extend their slender pliant branches considerable distances, and by this means often embracing, as it were, into one common bond, many of the loftiest and largest trees. . . . . Another characteristic of forests of this description is a thick undergrowth of numerous kinds of ferns and other plants. Palms and tree ferns also usually abound, the former reaching a height, in some instances, of at least 130 feet. . . . On the stems and branches of the trees numerous kinds of epiphytal ferns and orchids grow, which, with the other plants referred to, contribute materially to give such forests a very tropical appearance."[2]

It is clear from the association together of the *débris* of trailing Smilaceæ and Aroids, and from the remains of large Fan Palms and Ferns, that our Eocene bush growth must have been very similar to that described by Moore. The physical aspects of the former stations of Araucaria on the alluvial banks of the great Bournemouth River, and its probable extension along the east coast of the Submerged Continent, must have approximated to those it now occupies on the Brisbane River and the shores of Moreton Bay on the East Coast of Australia. Nothing can be more impressive, indeed, than the remarkable agreement in habit between the Araucaria and associated plants that have passed away, and those that survive so far away. The long-embedded plants of our Eocene coasts seem to have risen up and to live again in a distant country, and through what exists there we are able to picture the long sandy coasts, beaten by an ocean surf and fringed with dark-foliaged and gigantic Araucarias, Gum-trees, luxuriant Palms and Ferns, whose remains have helped to form the cliffs and moors of pine-clad Bournemouth. If we contrast this with the comparative absence of any similar associated vegetation in the Mammoth Grove, we see how opposed would have been the contemplated reference of these branches to Sequoia under any known natural grouping.

Dixon, in the 'Geology of Sussex,' pl. ix, fig. 1, engraved a fragment of a Coniferous branch under the name of *Lycopodites squamatus*, Brong., from Bracklesham, which might possibly have belonged to this species, and there is a small fragment from Barton in the British Museum.

A somewhat similar Conifer occurs in the Bembridge Marls of Hempstead Cliff, Isle of Wight. The needles are longer, straighter, and less symmetrical, and the species is evidently distinct from *Araucaria Goepperti*. Whether, however, it is the Icelandic *Sequoia Sternbergi*, or a *Cryptomeria* or a *Dacrydium* like that from Borneo, which very closely resembles it, there is at present absolutely no evidence to indicate.

[1] 'Industrial Progress of New South Wales,' 1870, pt. ii, p. 643.

[2] Id., p. 633.

Tribe VI.—ABIETINEÆ.

The genera *Pinus*, *Cedrus*, *Picea*, *Tsuga*, *Pseudotsuga*, *Abies*, and *Larix* are recognised by Bentham and Hooker in the *Genera Plantarum*, 1880. The tribe is most extensive, comprising some 150 species, including the Pines, Firs, Cedars, and Larches, and is almost exclusively confined to northern, and north temperate regions. There are no tropical species, and only one Pine in the Sunda Isles, including Sumatra, Java, and Borneo. The genera are all needle-leaved and cone-bearing, and with few exceptions produce winged samaroid seeds.

The Abietineæ did not make their appearance until after the other tribes of Coniferæ had long existed, and no remains of them are known of date older than the Jurassic. With the Wealden and Cretaceous periods they became plentiful, and already in the Neocomian and Gault the ancestors of several existing genera were completely differentiated. There are not wanting signs that in the later Tertiaries at least, they had acquired almost as great an extension as at present. The vast preponderance of fossil wood is, it is well known, coniferous, this being from its resinous nature capable of resisting decay, when immersed or buried, for a much longer time than ordinary Exogenous wood; but it is remarkable how very large a proportion of the Coniferous wood from the Tertiaries belongs to the Abietineæ, though the woods of other tribes surpass it in this property. Of upwards of a thousand specimens from the Brown-coal, examined by Goeppert, only three were not coniferous; and of all the woods from the underlying Amber-beds, only one could be referred to another tribe of Conifers.

It is difficult to estimate the area occupied at the present day by the Abietineæ, but in northern regions they are held to outnumber the broad-leaved trees by ten to one. In Europe *Pinus sylvestris* and *P. cembra* stretch from the most westerly Alps, across the Black Sea, to the Caucasus and Altai, and, uniting with *Abies sibirica* and *Larix sibirica*, form the colossal forests of Siberia, estimated at 1,200,000 square miles. In America the Pine-barrens stretch 300 to 500 miles uninterruptedly. In British North America, forests occupying 240,000 square miles are formed of *Abies nigra*, *A. canadensis*, and *Larix microcarpa*. Their colossal bulk and great economic importance have been already alluded to, but it was not mentioned that species of this tribe furnished the whole of the Amber of North Germany, and of these the value of the Samland deposits alone is estimated at £250,000,000.

The Abietineæ are represented in British Eocenes exclusively by the genus *Pinus*. It is remarkable that hardly any traces of them have been met with in any of the Floras in which leaves are preserved, their remains consisting only of cones, having, in the British rocks, been found almost exclusively in marine or estuarine deposits. The localities from which they have been collected are numerous, but except those from below

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BRITISH EOCENE FLORA.

BY

JOHN STARKIE GARDNER, F.L.S., G.S., M.G.S. France, &c.

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GYMNOSPERMÆ.

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the London Clay, they are generally macerated and abraded. They appear, without exception, to be unripe, or have not shed their seed, and may have travelled long distances before becoming finally waterlogged and embedded. It is therefore open to question whether the Pines from which they were derived were actually indigenous to our Eocene plains or low-lying grounds during the sub-tropical periods, or whether they might not, from the great length of time they would float, have been brought from more hilly countries by river, or even from other lands by marine currents.

The genus Cedrus comprises four species, or perhaps varieties, which inhabit respectively the Himalayas, the Lebanon, Atlas, and Cyprus mountains. The cones are globose and erect on the upper side of the branches. The scales are thin, leathery, and closely pressed together, and persist for some time after shedding the seed. The cones break up and the scales fall separately, except those of the apex, which are soldered together in form of a rosette. This habit may account for the complete absence of fossil Cedars in the Tertiaries; the older forms known from the Neocomian having possibly possessed persistent scales. Sections of Coniferous wood are figured in 'Dixon's Geology of Sussex,' pl. xvi, fig. 5, which were redescribed by Carruthers, ed. ii, p. 164, as *Cedroxylon Worthingense*. Picea has twelve to twenty-four species, with solitary acicular leaves and cones resembling those of the Cedar. They inhabit temperate regions throughout the northern hemisphere, almost to the confines of vegetation. Two Gault forms from Hainault are doubtfully referred to the genus, while fossil species are met with in Iceland and Greenland, the Wetterau Amber-beds, and a few other Miocene (?) localities. Tsuga resembles Picea, but possesses terminal and pendant cones. The five species inhabit Japan, the Himalayas, and North America, and are said to have been found fossil in the same beds as Picea. I have some doubtful cones from the Iron-ores of Ballypalady described at page 74 as *Tsuga Heerii*. *Pinus Crameri*, related to Tsuga, is the most widely spread fossil in the Arctic Cretaceous. The only species of Pseudotsuga inhabits from Mexico to Oregon. The eighteen species of Abies inhabit mountainous regions of northern and north-temperate regions. The scales are leathery and loosely imbricated and not persistent, as in Tsuga. Fossil species are known from the Jurassic and Wealden, and from Greenland, Iceland, and the European Miocenes (?). Larix possesses seven to ten species, with linear leaves, solitary or in bundles, and deciduous in all but one species. The cones are small, with leathery persistent scales, and fall in clusters with the dead branches. The Larch extends over the colder regions of Europe, Asia, and America. Three fossil species are described from the Miocene of Frankfort, and one from Austria.

Several of the *Abietineæ*, including the common Spruce, formed part of the British Flora in the Pliocene age, for their remains are met with in the Clays at Bacton, Norfolk. All died out, however, owing to unknown causes, except the Scotch Fir, truly indigenous in the Highlands, and were re-introduced by the agency of man.

Genus—PINUS, *Linn.*

The flowers are monœcious; the male flowers are produced in dense clusters or spikes at the extremities of the branches, and the female flowers either solitary or in whorls. The cones are ovate, conical, or oblong, generally sessile, persistent for a long while, solitary or in clusters, and varying in size from that of a walnut to a length of nineteen inches or even more. The scales are spirally disposed, numerous, woody or subligneous, generally thickened at the apex, persistent, closely imbricated, and gaping when ripe. The seeds are in pairs, two under each scale, and are more or less oval and pseudo-samaroid, or rarely wingless. The leaves are acicular, sometimes very long, and in sheaves of two, three, or five. The subdivisions, "Binæ," "Ternatæ," and "Quinæ," founded on the number of leaves in a fasciculus, and generally adopted as a basis of classification, are rejected by Bentham and Hooker as being based upon an inconstant character. The two natural sections, PINASTER and STROBUS, may be distinguished, the first by the woody nature of its cones, with scales closely pressed together before dehiscence, the heads rendered more or less quadrate by this mutual pressure, and with raised or depressed areola, and central umbo or mucro. The indigenous Scotch Pine, the introduced Maritime Pine, and nearly all the Pines of Europe, belong to this section. The Strobus Pines have cones of loosely-imbricated concave scales, leathery in texture, thickest in the middle and thin at the margins, and with minute or obsolete umbos. The Himalayan *P. excelsa*, *P. Lambertiana*, or the Sugar Pine, *P. strobus*, and *P. cembra*, are examples of the group.

The *Pinaster* section contains sixty or seventy recent species, and Schimper enumerates a still larger number fossil. The oldest forms are from Solenhofen; and the Gault of Hainault contains, according to Coemans, connecting links between the two sections.

Strobus appears to possess not more than thirteen living, and about twenty fossil species, the oldest of which is from the Neocomian of Greenland.

Pines are confined, like all the Abietineæ, to the Northern Hemisphere, but stretch into the neotropical region along the mountains of Mexico. They are quite absent from the Ethiopian and Australian regions, though one species ranges to Java.

Notwithstanding its exclusion from southern regions it has the widest range of any genus of forest trees, for it extends from the perpetual snows of the Arctic Regions to Mexico, where it mingles on the high grounds with Feather-palms, and to the southernmost points of Europe and Asia. A single species, *P. sylvestris*, stretches from latitude 70° in North Lapland and 65° 15′ in East Siberia to 36° in Persia, thus reaching over at least 34° of latitude and 150° of longitude. Frequently two species of Pine mingle to form

vast forests; and again species replace each other at varying heights, as on the Riesengebirge, where four different species of Pines and Firs inhabit separate zones.

Fig. 24.

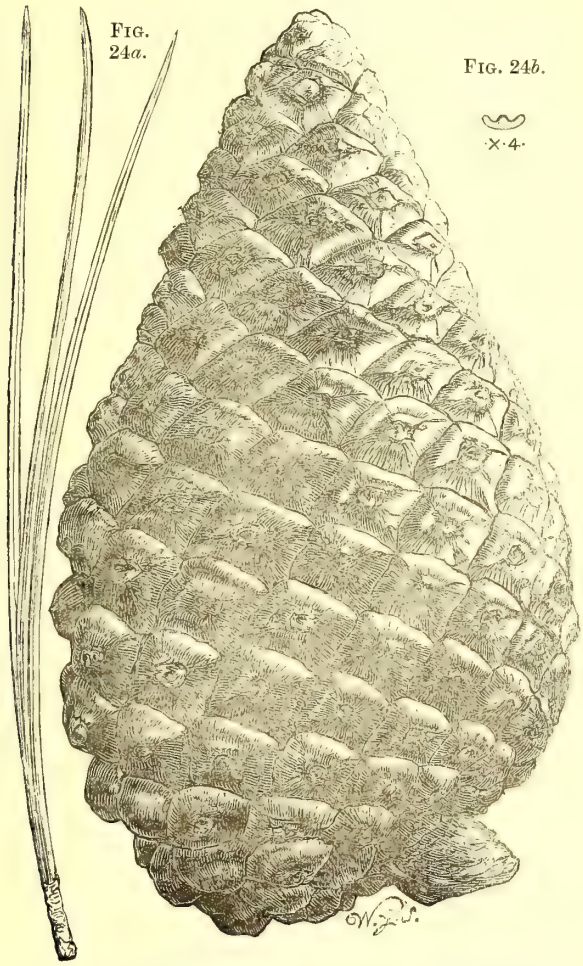


Fig. 24.—A Cone of *Pinus insignis* (of the *Pinaster* section), nat. size. *a*, leaves, nat. size; *b*, section of leaf, magnified 4 diameters. From the 'Gardener's Chronicle.'

Fig. 25.

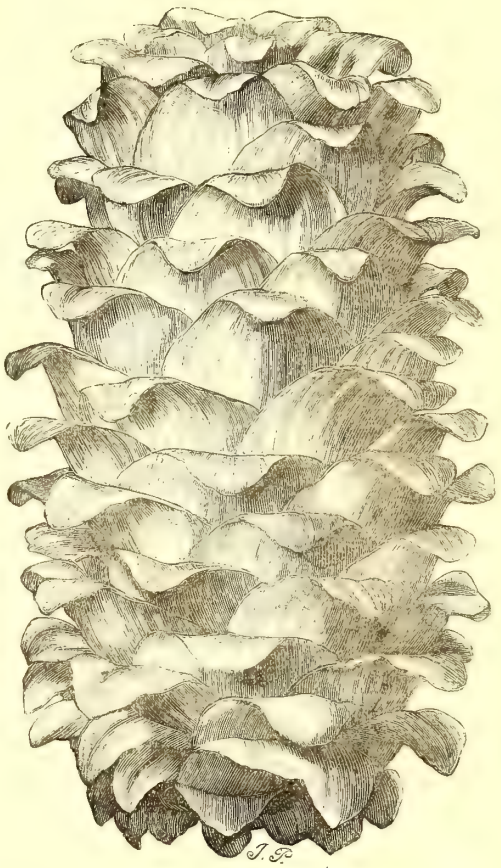


Fig. 25.—A Cone of *Pinus koraiensis* (of the *Strobus* section), natural size. From Veitch's 'Manual of the Coniferæ.'

Pinus macrocephalus, *Lindley and Hutton*, sp. Plate XIV, figs. 1, 2, 6, 7.

Zamia macrocephala, *Lindl. & Hutt.* Foss. Flora, vol. ii, p. 117, pl. 125, 1833–35.
Zamiostrobus macrocephalus, *Endlicher.* Gen. Plant., p. 72, 1836–40.
Zamites — *Morris.* Ann. Nat. Hist., ser. i, vol. vii, p. 116, 1841.
Pinites — *Brongn.* Dict. univ. d'Hist. Nat., p. 317, 1849; Ann. des Sc. Nat., ser. iii, vol. xi, p. 285, 1849.
Zamiostrobus Henslowii, *Miquel.* Monogr. Cycad., p. 75, 1861.
Pinites macrocephalus, *Carr.* Geol. Mag., vol. iii, p. 5, pl. xx, 1866; and Journ. Bot., p. 10, pl. xviii, 1867.

Thanet Beds, East Kent.

The cones are cylindrical, slightly tapering, blunt at both ends, and measure from eleven to thirteen centimètres in length by some fifty-five millimètres in breadth. They possess a somewhat slender axis, about five millimètres in diameter, from which the scales are given off at first at obtuse angles, and then, just beyond the seeds, bend sharply upwards with a slightly outward direction. The terminations of the scales are large, roughly hexagonal, ten millimètres thick, and about thirteen millimètres in diameter. Their surfaces are smooth and unornamented, but slightly convex towards the centre of the upper portion of the scale. Each scale supports two seeds in the hollowed inferior surface near its base, about half an inch long, and possibly wingless. A remarkable character about this and the following species is that the basal scales are larger than those of the body. Mr. Carruthers describes them as "barren, and the apophyses rise from their whole surface; in the series immediately above them there is a short flat body to the scale, but the greater portion of the scale is covered with the apophysis; the third series are fertile and have a longer and more ascending body." The cone has externally a cycadean aspect, but internally the structure is that of a true Pine. Corda appears to have first recognised its true nature in 1846,[1] and three years later Brongniart, having apparently received a specimen from Mr. Wetherell, still more positively stated, from the form and direction of the scales and the position of the double seeds at their base, that it was the cone of a Pine and not of a Cycad. The great size of the basal scales suffices to distinguish it from all existing Pines, but this character alone scarcely seems to warrant our placing the species in the doubtful genus *Pinites*, in which many of the Secondary Coniferæ find an appropriate place. Carruthers compares it to *Pinus pinea*, a very solid, bluntly ovate cone, five or six inches in length, containing large shortly-winged seeds, inhabiting the Mediterranean borders from Spain to Greece.

The fossils, through some vagueness as to their exact derivation, were once thought to be Cretaceous, but they are undoubtedly Eocene. Mr. Dowker showed me a very fine specimen which he obtained in a pit of nearly pure sand just above the Infirmary of the Canterbury Barracks, which was unfossiliferous at the time of my visit.

The specimen (fig. 7) is stated by Henslow[2] to have been "discovered in cleaning out a pond four miles from Deal, on the road to Canterbury." Mr. Dowker has, however, I believe, found more than one specimen *in sitú*, and is able to fix their precise horizon in the Thanet Beds, near Reculvers.

[1] Reuss, 'Verst. d. Boehm. Kreidef.,' 1846.

[2] Lindley and Hutton, 'Foss. Flora,' p. 117.

PINUS OVATA, *Lindley and Hutton*, sp. Plate XIV, figs. 4 and 5.

ZAMIA OVATA, *Lindl. & Hutt.* Foss. Flor., vol. iii, p. 189, pl. 226*a*, 1837.
ZAMITES — *Morris.* Ann. Nat. Hist., ser. i, vol. vii, p. 116, 1841.
ZAMIOSTROBUS OVATUS, *Goepp.* Uebersicht. d. Arbeit d. Schles. Ges., p. 129, 1844.
PINITES — *Carr.* Geol. Mag., vol. iii, p. 9, pl. xx, 1866; and Journ. Bot., pl. xviii, 1867.

Thanet Beds, East Kent.

The cone closely resembles *P. macrocephalus*, but differs in its smaller size and more ovate form. The specimen is imperfect at the base, but it seems to have possessed large basal scales like the last. The apophyses of the scales are more lozenge-shaped than hexagonal, and longer than broad. Carruthers had before him the transverse section, Pl. XIV, fig. 4, which exhibits "a slender axis, the centre of which is occupied with cellular tissue, and is surrounded by a cylinder of wood. Being transverse, the section cannot exhibit the disc on the vascular tissue, but it exactly agrees with transverse sections of recent cones. A regular series of large ducts are arranged symmetrically around the axis. Each scale supports two seeds. The tissue of these has entirely disappeared, the cavity being filled with carbonate of lime. Three other scales are seen beyond that bearing the seeds in section." The history of the species is similar to that of the last. The seeds seem rounder, and it is possibly a distinct species, though from beds of the same age. Mr. Richardson is said to have found it on the coast near Faversham. Owing to some curious misunderstanding it is recorded by Schimper as from a rearranged deposit near Lyme Regis, but probably of Tertiary age.

PINUS PRESTWICHII, sp. nov. Plate XIII, fig. 3.

ABIES SP., *Prestwich.* Quart. Journ. Geol. Society, vol. x, p. 156, pl. iii, fig. 3, 1854.

Thanet Beds, Herne Bay.

The cone is elongate, ninety-four millimètres in length, cylindrical, and tapers gradually from the widest part, twenty-one millimètres, to a very acute apex, and rather more suddenly to a small truncated base. The scales are flattened, without any trace of prominence or keels, and marked with irregular longitudinal striæ, either parallel or slightly diverging at the base. Their impressions are sub-hexagonal or with the upper margin rounded; the umbo must have been apical, and there are slight indications on one or two scales that it may have been mucronate. Their extreme width is twelve to

fourteen millimètres, and the height visible in the impressions but eight millimètres. The unique specimen known is a hollow mould in so small a concretion of ferruginous sandstone that the walls are only some five to seven millimètres thick. Inside this there was a lignitic core, casts of which have been made, though they are of little if any palæontological value. The mode of fossilisation is exceptional and difficult to understand, for the partings between the scales are incised on the mould instead of elevated, and the surfaces of the scales themselves somewhat convex, as if the walls of the mould had bulged as the vegetable tissue of the cone shrank away.

Fig. 26.—*Pinus monticola* (from 'Veitch's Manual,' p. 181).

The fossil clearly belongs to the Strobus section of Pines, and the species with which it is most comparable are *P. peuce*, growing in European Turkey at elevations of 5000 and 6000 feet,—*P. monticola* of Northern California, a species growing on Trinity Mountain at an elevation of 7000 feet, and on the banks of rivers in Oregon and Washington Territory,—*P. strobus* of Canada to Virginia, and *P. excelsa* of the Himalayas, at elevations of 6000 to 12,000 feet. All these are quite hardy, and the presence of the fossil in the Thanet Beds is therefore corroborative of the relatively temperate climate of that period.

I am not acquainted with any fossil cone sufficiently near it to enable a useful comparison to be made. The original specimen in still in Professor Prestwich's collection, and I am indebted to him for the opportunity of describing and refiguring it.

Pinus Dixoni, *Bowerbank*, sp. Plate XIII, figs. 1, 2, 4, 5, 8.

Pinites Dixoni, *Bowerbank*. In Dixon's Geol. Sussex, ed. 1, p. 84, pl. ix, fig. 3, 1850.
— — — Ibid., ed. 2, p. 162, 1878.

Middle Bagshot, Bracklesham; Bembridge Marls, Gurnet Bay, Isle of Wight.

The specimen originally figured is still preserved in the Botanical Department of the British Museum, though in a very imperfect state. It was described by Carruthers[1] as

[1] Dixon, 2 ed., p. 162.

"elongated, sub-cylindrical, swollen towards the base; five inches long, one and a half broad on the upper half. Scales thickened at the apex, with a rhomboidal obtusely spinous apophysis." Fig. 8, Plate XIII, represents a rather obscure specimen from the Fisher collection in the Woodwardian Museum, Cambridge, and shows the apophyses to be rhomboidal, transversely carinated, and umbonate; it measures about fifteen centimètres in length, by seven or eight centimètres across, having at least ten scales to a whorl. When redescribing Dixon's specimen, Mr. Carruthers remarked that "on the left side, and at the base, the cone has been abraded, the apices being lost, so that in estimating the form of the perfect cone allowance must be made for the missing parts. It is obvious that, when these scales were perfect, the diameter of the cone must have been considerably greater at the base than is shown in the figure." It is difficult, however, even making full allowance for their imperfect condition, to reconcile the very long cylindrical form reproduced in the woodcut Fig. 27, with the pyramidal outline of Fig. 8, Pl. XIII.

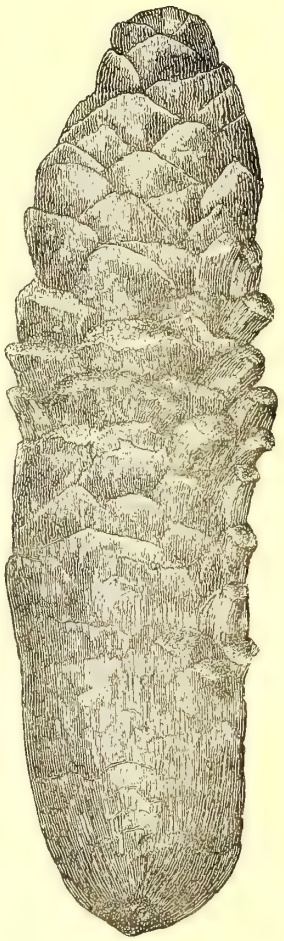


Fig. 27.—*P. Dixoni*; Bracklesham. Dixon's 'Geol. Sussex.'

A smaller and better-preserved specimen, from the Woodwardian Museum, Pl. XIII, figs. 1 and 2, represents almost the entire cone, with a length of eighty-five millimètres, and a breadth of forty millimètres, composed of about 112 scales. The form is ovate, but a slight allowance has to be made for compression. The apophyses of the scales are very similar to those of *P. sylvestris;* the largest measures twelve millimètres by eight millimètres. Another specimen, in the British Museum, labelled from the Isle of Wight, but which must apparently have been obtained either at Highcliff or Bracklesham, has even smaller apophyses, almost suggesting another species, to which the small axis from Highcliff, Pl. XIII, fig. 5, may also have belonged.

The larger cone, Pl. XIII, fig. 4, obtained by Mr. J. A'Court Smith, from Gurnet Bay, near Cowes, presents no characters which allow it to be separated specifically from *Pinus Dixoni*, of the Bracklesham Beds. The scales were more widely dehiscent than in the other examples, and their apophyses are in every case abraded, except towards the top of the cone, where they are almost concealed by pyrites. When visible in this and in a second specimen, however, they are seen to be quite similar to those above described. What remains of the cone is six inches long, nearly cylindrical, somewhat pointed at the apex, obtusely rounded at the base, and composed of fourteen whorls of about ten scales.

It is, perhaps, worth remarking that all the Bracklesham and the two Gurnet Bay

cones have lost their basal scales, as if they had suffered decay on land or abrasion in rapidly moving streams before reaching salt water.[1]

The fossils bear a considerable resemblance to *Pitys Haidingeri*, pl. xix, 'Unger Chloris Protogæa,' p. 73, from Leoben in Styria, and very little doubt can exist as to their identity with *Pinus Defrancii*,[2] Ad. Brongn., from the "Calcaire grossier," of Arcueil, in the Paris Basin. *Pinus hordeacea*, Rossner, from Tschnernowitz, in Bohemia, is also not dissimilar.

The nearest existing species seem to be *P. laricio*, *P. pyrenaica*, and *P. halepensis*, Pines belonging essentially to the Mediterranean region.

P. Dixoni, if all the specimens are correctly placed in the same species, would range from the Bracklesham to high up in the Bembridge Marls, but it is not improbable that a good series of more perfect specimens might lead to the recognition of more than one species.

PINUS BOWERBANKII, *Carr.*, sp. Plate XIII, figs. 6 and 9; Plate XIV, figs. 3 and 8.

PINITES DIXONI, *Bowerbank* (pars). In Dixon's Geology of Sussex, ed. 1, p. 84, pl. ix, fig. 4, 1850.
— BOWERBANKII, *Carruthers*. Ibid., ed. 2, p. 163, 1878.
PINUS SHEPPEYENSIS, *Ett. & Gard.* Proc. Royal Society, No. 198, 1879.

London Clay, Sheppey; Middle Bagshot, Bracklesham and Highcliff.

This Pine is so far only known from very mutilated specimens, and the original example figured in the 'Geology of Sussex' no longer exists. Dixon's figure does not in all probability exhibit the true apices of the scales, for they are represented merely as bluntly recurved, without umbo, but considerably thickened, forming a type of scale unknown in the genus *Pinus*. The similarity in the breadth and form of the scales and of the cone generally have induced me to unite with it a specimen in which a few scales are perfect; they are of somewhat crescentic form, two centimètres broad, transversely keeled, and with small recurved mucronate umbo.

Mr. Carruthers, in separating it from *P. Dixoni*, Bow., described it as "ovate (?) or oblong (?). Scales very large, broad, and cuneate; apex broad, flat, and with a recurved edge; covered part of the scale large, and deeply imbricated." He also suggests that it might be only the upper portion of a very large and long cone, but I scarcely think this can have been the case, and I am inclined to believe that nearly the entire axis is present in the specimen figured in Plate XIII, fig. 9.

[1] Whether the decay is due to such causes, or to the ravages of birds or squirrels, the basal scales are the first to suffer.

[2] 'Mém. du Mus. d'Hist. Nat., vol. viii, p. 325, pl. 17, fig. 8, *a*, *b*.

The Sheppey specimens are still more fragmentary, and add nothing to our knowledge of the size and external form of the cone, and only one presents a few perfect scales. These are also about two centimètres broad, and with heads resembling those of the Bracklesham specimen (Pl. XIII, fig. 9). Other specimens (Pl. XIV, figs. 3 and 8) show a very stout axis marked deeply with pear-shaped scars and rather large and winged seeds. The fragment (Pl. XIII, fig. 6) from Highcliff doubtless belongs to the same or a very similar species.

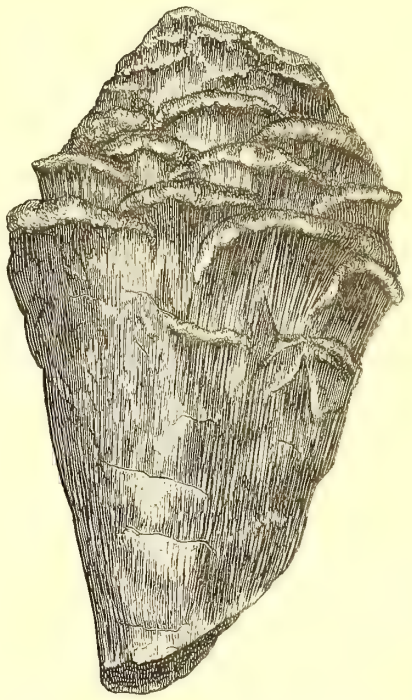


Fig. 28.—*P. Bowerbankii.* 'Dixon's Geology of Sussex,' edit. 2.

The resemblance between the Bracklesham and the Sheppey and Highcliff specimens, justify, in the absence of any distinguishing specific characters, their being grouped under one name. Whether they should be united with *P. Bowerbankii*, of Carruthers, is far more open to question, and indeed, if Dixon's figure were an absolutely reliable representation, it would be manifestly improper to do so; but I know from experience how difficult it is to interpret and restore an imperfect and abraded cone in the condition of soft and perishable lignite, and I think that with our present material the multiplication of species is best avoided. The late Dr. Bowerbank remarked on the difference between Dixon's two specimens from Bracklesham, but abstained from separating them specifically.

Carruthers places it in the *Cembra* division of Strobus, distinguished by its wingless seeds; and Bowerbank considered both the Bracklesham Pines to be allied to the tender *P. Russelliana* of Mexico. The specimens I have united with it, however, clearly belong to the Pinaster section of the genus.

It is rare at Bracklesham, but Mr. Keeping tells me that cones are occasionally abundant at Highcliff. It is also very rare at Sheppey, where the presence of seeds *in situ* shows that the cones were not originally deposited in a mutilated condition.

Pinus Plutonis, *Baily.* Plate XV, figs. 1, 3, 4, 6, 7, 8; Plate XVI, figs. 5—7, and 17; Plate XVII, except fig. 4; and Plate XVIII.

Pinus Plutonis, *Baily.* Quart. Journ. Geol. Soc., vol. xxv, p. 360, pl. xv, 1869.
— Graingeri, *Baily.* Report of Brit. Association, pl. ii, 1880.

Basaltic Formation, Ballypalady, Antrim.

The remains of this fine species are very perfect and abundant.

The cones vary from seventy to ninety millimètres in length and twenty to thirty millimètres in diameter,—are cylindrical, tapering slightly towards the apex, rounded or rarely truncate at base,—and composed of between 120 and 140 scales. The scales are about twenty-five millimètres long, and ten to fifteen wide, but much smaller towards the extremities; the heads are sub-hexagonal or rounded on the upper margin, wider than high, flattened, with slightly elevated but distinct transverse ridges across the centre, culminating in a small, lozenge-shaped umbo, with traces of an ill-defined central tubercle. The cones are usually detached, more rarely in twos, and in the fine specimen (Pl. XV, fig. 3) obtained by Mr. Stewart, F.L.S., for the Belfast Museum, three are clustered together, appearing to grow upward and parallel to the stem. The seeds are oval and moderately large, about five millimètres in length or twenty millimètres, including their almost parallel-sided, rectangular wing (Pl. XVII, figs. 2, 3, 5, 8). The leaves are two in a sheath, rather slender, from ten to fifteen centimètres in length, and are often found in dense tufts adhering to the branchlets. The branchlets (Pl. XV, figs. 3 and 4) are closely inlaid with crowded and symmetrical leaf-scars, exhibiting the usual seasonal variations. A fragment of bark with larger scars is represented (fig. 7 of the same plate).

The scales of the cones are mostly closed, in which case very little lignitic matter remains, and the specimens are in the form of compressed hollow cavities exhibiting perfect moulds of the exterior of the cone. The example upon which *P. Graingeri* was founded was merely the shrunken lignitic matter out of one of these cavities. In other cases the cones had gaped, and the matrix has infiltrated between the scales, either filling the spaces left vacant by the shedding of the seeds, or replacing them with soft mud, prior to the decay of the woody tissue of the cone itself. Some examples found in this condition are certainly cones of *Pinus Plutonis*, for impressions of the thickened ends of the scales can be traced out, but in the specimens figured (Pl. XVI, figs. 5, 6, 7, 17), I have been unable to trace any thickening, and either therefore their more solid parts decayed while the matrix was too plastic to retain an impression, or the cones had thin scales and were allied to *Tsuga*. Their size and general form, and that of the seed, favour the former alternative. Heer described in 1855 cones similarly preserved in white sandstone from the Lausanne Tunnel (*Pinus Lardyana*, 'Flora Tert. Helv.,' vol. i, p. 58, pl. xx, fig. 5), and those I have figured from Sheppey (Pl. XIV, figs. 3 and 8) illustrate a stage in the process of decay in which nothing of the cone remains but the clustered seeds and the axis. In the Ballypalady cones a further stage has been reached in which the axis also has disappeared, and only casts of the seed-cavities remain. In this condition little resemblance to Pine cones is at first sight apparent, except the arrangement of the seeds in pairs. Cones in this condition have obviously no palæontological interest, and I should barely have referred to them were it not probable that similar specimens from Greenland have been mistaken for cones of Magnolia. Two such, brought from Greenland by Mr. Whymper (Heer, 'Flor. foss.

Arctica,' vol. ii, p. 478, pl. li, figs. 2 and 3, reprinted from the 'Phil. Trans.,' 1869), bear a striking resemblance to the Ballypalady Pine cones, while possessing little or no structure to support a contrary view.

The fruit of Magnolia consists of a number of carpels or follicles in a compact spike, which open along their outer edge to allow of the escape of the seed. In *Magnolia grandiflora*, to which the fossil is compared, the deciduous sepals and petals leave deep scars in falling away, forming a characteristic region on the stem immediately beneath the fruit, and the seeds are arranged not spirally, but horizontally in whorls, at right angles to the axis. The characteristic impress of a Magnolia fruit, whether the carpels were dehiscent or not at the time, would be the external, and not an internal cast, such as those met with in Greenland. Heer, in describing them, only says that the cones are "much resembling those of Magnolia," and that several of the "carpels show the fissure, precisely as in *Magnolia glauca*." The supposed fruits were not found in the same locality with the supposed leaves. It is easy to see how the division between two pine seeds might be mistaken for a fissure, and it is not impossible that the previous determination of Magnolia leaves may have led to an identification that might otherwise not have suggested itself. The specimens were unfortunately not returned, and the question of their true nature therefore remains open,—a fact to be regretted, since much stress had been laid on their presence to support the rather excessive estimate of the mildness of climate in high latitudes during the Tertiary period.

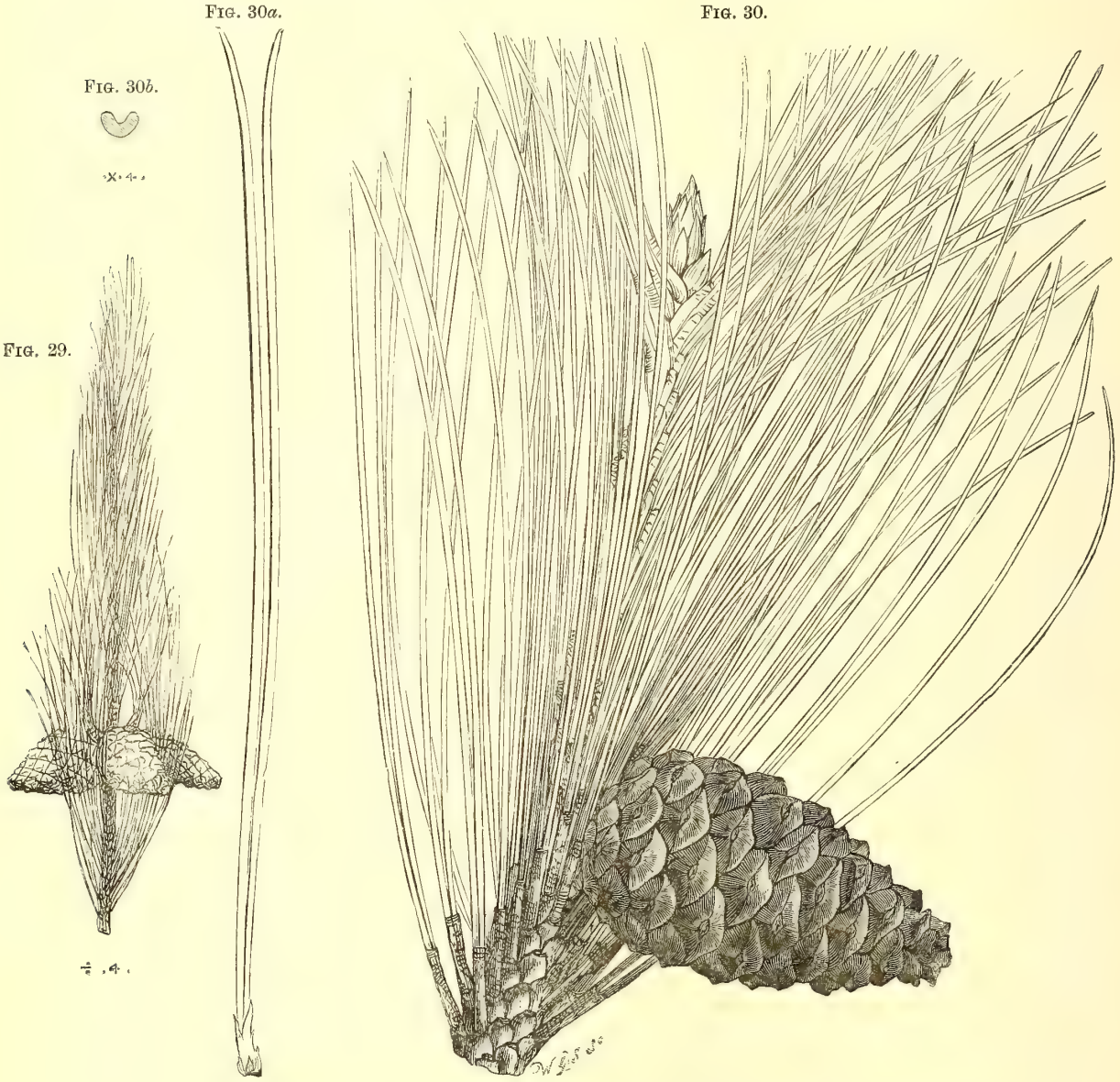
Pinus Plutonis bears the greatest resemblance to the less hardy of the living species of Pine. *Pinus sinensis*, of Hong Kong, differs chiefly in its slightly smaller cones and seeds, and more slender needles. *Pinus laricio*, an inhabitant of the Mediterranean and of Western Asia, varies in the more pyramidal form of its cones and the greater size of the heads of its scales, the needles and the scars left by them on the branchlets being nearly identical. *Pinus halepensis* is identical with it in the size and ornamentation of its cones and scales; but, while our cones are less pyramidal and apparently grow in an upward direction (Pl. XV, fig. 3), those of *P. halepensis* grow in pairs inversely downwards. The seed-wings of the fossil (Pl. XVII, figs. 2, 3, 8), are more rectangular and less obliquely truncated at the extremity than are any of those of the existing Pines which otherwise resemble it. The needles are very much the same as those of *P. halepensis*, and perhaps a trifle more slender than those of *P. laricio*. Our fossil must thus be regarded as a different, but closely allied species, and requiring probably a similar mean temperature.

P. halepensis is usually a low-spreading tree in habit, from twenty to thirty feet in height, though some of its varieties form much loftier trees, and ripens its cones in the autumn of the second year. It is common in the Mediterranean region of Europe and Asia Minor, but is not found north of the Apennines nor at elevations above 2000 feet.

Ettingshausen has endeavoured to trace a genetic connection between the Pines of the various Tertiary formations of Austria, especially of Leoben in Styria[1] and existing

[1] 'Beitr. zur Erforschung der Phylog. der Pflanzelementen,' 1877.

Pines. He divides the formations into four horizons, the oldest of which is characterised by, among others, *P. palæo-laricio*, the second by *P. hepios*, and the third and fourth by *P. laricio*. He gives no illustrations of the cones of the former species, but our seeds



Figs. 29, 30.—Fertile branchlet of *Pinus austriaca*; 29, one fourth natural size; 30, natural size; 30*a*, leaves, natural size; 30*b*, section of leaf, magnified 4 diam. (From the 'Gardener's Chronicle.')

agree more closely with those figured than with any existing seed. The fossil that appears most close to it is a cylindrical cone from Kumi in Eubœa, figured as *Pinus hampeana*.[1] The seeds and cone, as figured, differ in several respects, however, from those of *P. Plutonis*, and from Unger's earlier description of the species.

[1] Unger, 'Foss. Flor. Kumi,' pl. ii, fig. 13.

PINUS BAILYI, sp. nov. Plate XV, figs. 2, 5, 9; Plate XVII, fig. 4.

Basaltic Formation, Ballypalady, Antrim.

This species is far less abundant than the preceding. The cones are small, elongate, cylindrical, slightly curved, fifty-three millimètres in length, sixteen millimètres in diameter, without footstalks, obtuse at both ends, and composed of about sixty-five or seventy scales. The heads of the scales are sub-hexagonal, very flattened, and without any transverse keel or other ornament except an inconspicuous central umbo and some slight longitudinal striæ. The largest scale-head measures nine millimètres across and eight millimètres in height, and the sizes diminish towards the extremities. The shorter needles found at Ballypalady are in pairs and from five to eight centimètres in length (Pl. XVII, fig. 4), and, like the tufted branchlets (Pl. XV, fig. 2) and the slender branchlet (fig. 9), may belong to this species.

The characters that serve to distinguish it from *Pinus Plutonis* are quite apparent, and consist principally in the smaller number of scales that compose the cone, their plain and flattened heads with inconspicuous ornament, and probably the shorter foliage. Like many fossil species, this cone is much more cylindrical or less conical than existing forms of the PINASTER section. I am unable to find any nearer living ally than *Pinus patula*, of Mexico, but this agrees with the fossil simply in the cylindrical and obtusely pointed form of the cone, and the almost unornamented scale-heads, but not in other respects.

No fossil at all resembling it has hitherto been described. It is relatively rare at Ballypalady.

Genus—TSUGA.

The genus was defined by Carrière to receive certain species of *Abies*, characterised by small cones with persistent scales, and flat, more or less two-rowed leaves. There are but five existing species, and these are confined to North America and Asia, the best known being perhaps *Tsuga Sieboldii*, of Japan, and the Indian Hemlock, and the Canadian and the Californian Hemlock-spruces. They are handsome trees, growing at considerable elevations and of large size, some reaching a height of 150 feet. No remains of them had been found in any rocks within the scope of this work until the past winter, when the specimens to be described were brought to light at Ballypalady in Antrim.

Tsuga Heerii, sp. nov. Plate XVI, figs. 1—4, and 10—16.

Pinus MacClurii, *Heer* (pars). Flora foss. Arctica, vol. vii, p. 65, pl. lxxxvii, fig. 3, 1883; non *P. MacClurii*, Heer, ibid., vol. i, pl. figs. xx, 16—18, p. 134, 1868.

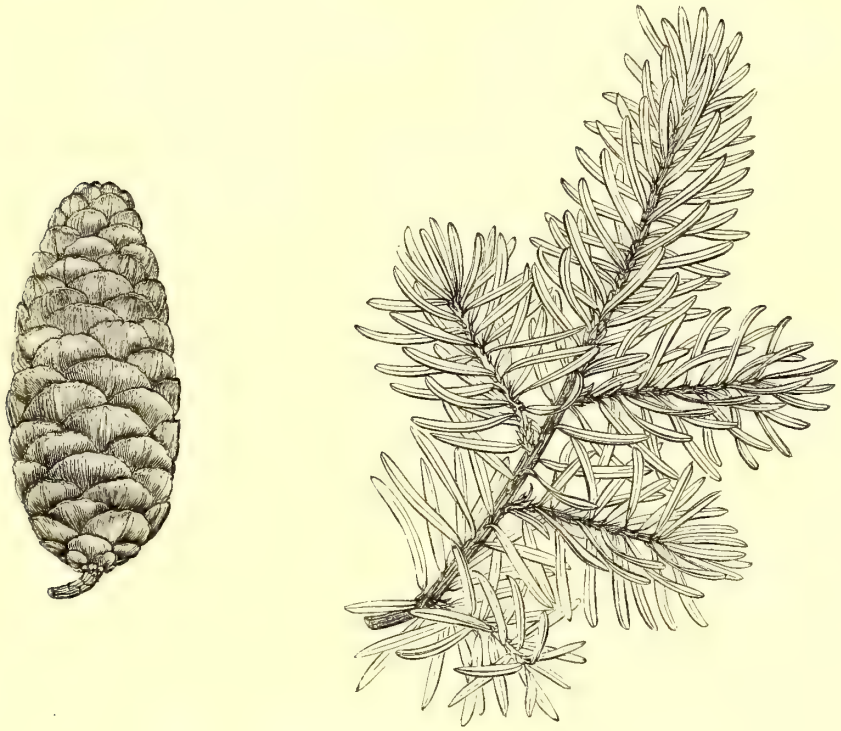
Basaltic Formation, Ballypalady, County Antrim.

The cones represented on Pl. XVI, figs. 1—4, though apparently dissimilar, agree somewhat in form and in the relative strength and position of the footstalk, and are all composed of thin, leathery scales. They may indeed belong to several species, but it is not wholly impossible for them all to have belonged to one, though perhaps shed at different stages of maturity. The scanty and imperfectly preserved material does not in any case afford data for separate specific determination, and it is therefore convenient to group them together. Fig. 1, Pl. XVI, is a cone sixty millimètres in length and twenty in diameter, seated on a short, stout footstalk, and composed of numerous loosely imbricated, thin, apparently leathery acales, pointed as in *P. monticola* (Woodcut, fig. 26), and striated and spoon-shaped to receive the seed. Fig. 2, Pl. XVI, is a slender, ovate, elongate cone, tapering to the extremities, thirty-five millimètres in length and fifteen millimètres in breadth, erect on a short, stout footstalk. The scales are imbricated, thin, leathery, about forty-eight in number, elliptical, with entire margin, seven millimètres across, but becoming very small towards the base, and irregularly but distinctly striated longitudinally. A similar though larger cone was described as *Elate austriaca*,[1] a genus founded by Endlicher on account of the wood-structure, which he considered to be nearer that of the *Larch* than of any other conifer. Fig. 3, Pl. XVI, is a closely imbricated cone, fifty millimètres in length and about fifteen in diameter, curved, very pointed, and seated on a stout footstalk. It is difficult to make out the form of the scales, as they are not separable in the specimen, but they are deeply striated longitudinally, and were possibly fringed. Fig. 4 of same Plate is more like fig. 1, and seems to have possessed broad, thin scales and large seed.

Fig. 1 might possibly be a *Pine* of the *Cembra* section, though I have not seen any species of such relatively small dimensions. Fig. 2 somewhat recalls *Tsuga jessoënsis*, and also the *Larch*, though its stem has not the external appearance so characteristic of that genus. The scales of fig. 3 might have been fimbriated, or the presence of bracts may have caused this appearance. On the whole, there is no genus they can be more satisfactorily placed in than *Tsuga*. Figs. 5—7, Pl. XVI, are referred to under *Pinus Plutonis* (p. 70), though their apparently leathery scales seem to ally them more especially with the cones above described. Casts of undoubted Pine are found in precisely the same state of fossilisation, and it is difficult to determine definitely whether

[1] Unger, 'Chloris Protogæa,' pl. xix, figs. 1—8, p. 70, from Niederwallsee, Lower Austria.

they are cones of *Fir* or of *Pine*. Figs. 10, 12 and 13 are acutely pointed acicular leaves, measuring respectively 20 × 2, 30 and 40 × 3 millimètres. The two former especially agree with the leaves of *Tsuga*, though the appearance of a double mid-rib seems to suggest *Sciadopitys*. Fig. 11 is a somewhat wider leaf, measuring 25 × 4 millimètres.



FIGS. 31 AND 32.—*Tsuga Pattoniana* (Veitch's 'Manual of the Coniferæ').

Fig. 16 is a small, elongate, narrow seed, with an ample, thinly membranous, pseudo-samaroid wing, twenty-six millimètres long and ten millimètres across at its greatest breadth, belonging apparently to some larger scaled cone than any of those figured. Figs. 14 and 15 are striated scales with entire margins, twenty-four millimètres in length by twelve in breadth. The seed is apparently of *Abies*, and the scales may be of the same genus, or possibly of *Pinus*.

Several cones, differing equally from each other, and with thin, leathery scales, have been figured by Heer in the "Flora fossilis Arctica," under the name of *Pinus* (*Abies*) *MacClurii*. The first were described from Banksland in 1868, and are small and cylindrical, with very numerous scales; the next was a small pointed cone with large scales and seeds from Netlvarsuk, in Greenland, published in 1874; and the third from Hare Island, identical with our Fig. 2, and published in 1883.

I have named my specimens provisionally after the late Professor Heer, with the reservation that, should it subsequently be found possible to define the thin scaled cones

more exactly, and to separate them specifically from each other, the name is to remain attached to the form shown in fig. 2 of Plate XVI.

The species belonging to the Cupressineæ, Taxineæ, and Taxeæ, to be described in the following pages, are somewhat out of their proper sequence,[1] but it appears more convenient to take them now while we are occupied with the Gymnospermæ, than to postpone their publication until that possibly indefinite future when all the Families of Plants shall have been disposed of in rotation, and the inevitable Supplement commenced. Various considerations, geological and palæontological, of both physical and theoretical nature, had led me to the belief that the determination of the newer Fossil Floras of Ireland and Scotland as Miocene rested upon no sufficient data, and that they might well be of such antiquity as to come within the scope of the present work. Visits to Dublin and Belfast convinced me that the existing collections were wholly insufficient for descriptive purposes; and, with the aid of a grant from the Royal Society, I have therefore set to work to obtain an adequate representation of these Floras. This work is still in progress, but the results so far comprise many hundred specimens, and the Coniferæ among these, supplemented by others obtained for the Belfast Museum, by that thorough botanist, Mr. S. A. Stewart, are now figured.

So little is generally known, even to those most interested in fossil plants, respecting the deposits of Ireland and Scotland from which those under consideration are derived, that it will enable us to understand them better and therefore invest them with a higher interest, if I briefly describe their chief geological features here, and the reasons which render it impossible, or at least inexpedient, to exclude these Floras from the present Monograph. The consideration of this question has the additional advantage of bringing home to us the imperfection of our knowledge on all subjects connected with fossil plants, and the futility of attempting as yet to infer from them the relative ages of rocks. It is encouraging, however, to believe that our present ignorance will sensibly lessen as this work progresses; for, as already pointed out, nowhere else in the known world is so vast a series of plant-remains intercalated among strata whose ages are absolutely known. It would indeed be singular, if some at least among them, when properly determined, do not take rank as landmarks side by side with fossils of the Animal kingdom.

In England we have not hitherto had to depend much upon plant-remains for our

[1] The publication of the present Monograph, while collecting is still in progress, is attended with considerable inconvenience, and its continuity is to a great extent destroyed. This is unavoidable, however, for it must be borne in mind that, as plants are imbedded piecemeal, we are often far from knowing as much of the organism even when many specimens have been obtained, as a single specimen would usually reveal among the Invertebrata. Years of collecting may yield nothing but detached leaves, fruits, or flowers, their connection being merely matter of inference, until some day the exact specimen required to convert inference into fact is unexpectedly discovered. Thus the collection of fossil plants can never be considered complete so long as the beds containing them are accessible, and their description and publication must either be undertaken with these inherent drawbacks or postponed to a time that would ever recede.

determination of the ages of strata, and their importance has thus come to be regarded in this country as trivial or at least subordinate. The fact, more and more apparent every day in other countries, and now brought home to us in Ireland and in Scotland, that the determination of the ages of strata of vast area and thickness sometimes rests entirely on the plants imbedded in them, must eventually, however, open our eyes to their importance, and those who contribute in any way to the advancement of their study will have the satisfaction of contrasting our present knowledge and estimation of them with what we may anticipate it to become when this work has reached its conclusion.

The Basaltic Formation of Ireland and Scotland.

The Basalts of Ireland have frequently formed the subject of communications to local and other scientific bodies. Their authors have, however, been uniformly satisfied to accept the current opinions as to their age, based upon the scanty and imperfectly understood plants found in them; and none of the descriptions are of an entirely comprehensive or exhaustive character. The Scottish Basalts have been more broadly treated of by Professors Geikie and Judd; but, as with those of Ireland, no clue to their precise age exists, except their plant remains. The only locality hitherto known to yield them in a satisfactory condition is Ardtun Head, in Mull; but a locality in the Isle of Canna has been discovered which may supplement the former Flora. The leaf-bed here forms the roof of a small cave, and the specimens obtained have become very friable from exposure to weather. I think it will be better to defer the description of the Scotch Basalts until I have been able to visit personally and collect from the new locality.

The Basalts of Ireland extend over an area that is roughly estimated at 1200 square miles, comprising nearly the whole of Antrim and portions of the adjoining counties of Londonderry and Tyrone. They form an elevated plateau bounded for the most part by noble escarpments with precipitous flanks, rising to elevations of 1000 and 1500 feet. Their total thickness is but 1100 feet, though these igneous rocks are estimated to reach in Mull not less than 3000 or 4000 feet.

These Basalts are but a small fragment, the mere southern limit, of a series of stupendous outpours of lava that once extended probably in an unbroken mass northward through Scotland and the Faröes to Iceland, where they are of unknown thickness. Nor would this represent their extreme limits, as may be seen in Scotland, where innumerable dykes diverge from them and penetrate through England to the North Sea. Their northern extension is as yet unknown, and their boundaries may probably have to be traced in Greenland and even Spitzbergen. Vast as this area is, it is not wholly without parallel elsewhere. A region in the Deccan, 200,000 square miles in extent, has been converted into a plateau of horizontal sheets of Basalt whose aggregate thickness is 6000 feet. These Indian flows are of Cretaceous age, and therefore preceded ours; but in

Oregon another enormous tract, estimated to equal the whole united areas of France and England, has been overwhelmed, and become an undulating plain of Basalt at so recent a date that it has been thought likely that the latest flows may have taken place within the human period. All these are believed to have welled up from great fissures, for no conceivable number of cones or craters would be adequate to produce such vast, level, and continuous sheets. They are termed "massive eruptions," and "represent the grand fundamental character of vulcanism, modern volcanic cones being regarded as merely parasitic excrescences on the subterranean lava reservoirs, very much in the relation of minor cinder cones to their parent volcanoes."[1] The distinguishing feature of lavas erupted in this way is their horizontal bedding and the rarity and massive size of the intersecting dykes, contrasted with those which are found diverging in all directions from true craters that have been denuded of ash.

The Basalts of Ireland were not erupted at one period, but have been grouped by Prof. Hull into three classes, the oldest of which includes highly silicated felspathic trachytes, porphyry, pearlstone, and pitchstone. The second comprises beds of basic amygdaloid, with bands of bole, volcanic ash, &c. The third is formed of massive sheets of columnar Basalt. A long interval, marked by the changed characters of the lavas, is supposed to have intervened between these stages. Be this as it may, considerable intervals of time are indicated by the boles, lithomarges, and lignites, which must each mark at least an interval sufficiently long for a considerable depth of the compact Basalt to have decomposed into vegetable mould, and remained, perhaps for ages, a soil on which a luxuriant vegetation flourished; while the lignites and even true coals, six or seven feet thick, found in them, must mark still greater intervals. The eruptions of Basalt were succeeded, at least in Scotland and Iceland, by trachytic flows, which seem to have ended the great period of volcanic energy to which the plants under notice belong.[2]

The enormous period required to build up masses many thousand feet thick, and stretching over 1000 miles in a direct line, may not unreasonably be supposed to represent an entire geological epoch; but a yet vaster time must have been required to sculpture the once continuous sheets into their present contours. This has not been effected to any appreciable extent by upheavals or dislocations; but the mountains have been carved out of the solid, inch by inch, by the slow process of weathering, which has cut down through them to a depth of over 2000 feet. River-valleys had been weathered out of them, according to Geikie, before the trachytes of the Scur of Eigg were erupted. The plateau-like aspect, still maintained in the Basaltic area of Ireland, has been lost in Iceland, where denudation has cut them into long rolling hills, separated by wide and nearly parallel valleys. The denudation is colossal, and solitary pinnacles or protuberances everywhere attest, like monuments, the former presence of Basalts, of which

[1] Geikie, 'Text-Book of Geology,' 1882, p. 256.

[2] The present localised manifestations in Iceland are as utterly disconnected from the Tertiary Basaltic outpours as an outbreak in Ireland to-morrow would be.

no other trace remains. The Faröes are even more eloquent of waste. This little group of some twenty islands and islets presents the ruins of a once continuous plateau, 2000 or more feet in height. The hills, as in Iceland, are usually flat-topped, but the cliffs, frequently 1000 and sometimes 2000 feet high, are almost vertical, and are fretted, especially on their western faces, into weird and fantastic forms. The sub-aërial waste is here supplemented by the attacks of the waves, and the sea for miles round is shallowed by the redeposited silt.

"Some of the noblest hills of the Inner Hebrides are but solitary outliers left standing amid the ruin of the great sheets of solid rock of which they once formed a part. Ben More, in Mull, though more than 3000 feet high, is only a magnificent fragment of the huge pile of volcanic material which formerly swept over what are now the deep glens and fjords of Mull. The long lines of imposing cliff with which the basalt plateaux front the Atlantic all through these islands, from the Fair Head of Antrim to the far headlands of Skye, tell everywhere the same tale of vast and continuous denudation."[1] "But most strikingly of all is this fact of enormous denudation of the Scottish Highlands during very recent geological periods, demonstrated by the occurrence of post-Miocene faults, having downthrows of various amounts up to nearly 2000 feet, the effect of which upon the surface has been entirely masked by post-Miocene denudation."[2] When we reflect that even this colossal denudation may be insignificant to that effected over tracts which are now sea, or to that which has acted over land-surfaces which no longer present any shreds of Basalts, except the dykes through which they welled, we feel compelled to stretch back our conception of the time during which the causes may have operated to the uttermost possible limits.

These limits cannot go beyond the White Chalk, for the lavas rest upon its denuded surface or upon the capping of angular flints and loam, which denote its former exposure to atmospheric influence. In Scotland, moreover, according to Judd, the Upper Chalk is covered by intervening estuarine and coal-bearing strata, sufficing to negative the idea that the Basalts were in any way contemporaneous with the Cretaceous series as developed in Great Britain. There is no physical evidence, however, against their belonging to any part of that vast period which intervened between the British White Chalk and the British Eocenes, nor to any stage of the Eocenes; but they do present evidence of such great antiquity that we ought to hesitate to assign them to any later period unless very good reasons for doing so were apparent.

The plant evidence upon which they were classed as Miocene has always been of the weakest description; and, had any of the geologists who have written about them troubled to look into it independently, the conclusion as to their age would never have been accepted. It was somehow assumed that the Antrim plants were on the same horizon as the Mull plants, and that since the latter were said to be Miocene the former

[1] Geikie, 'Quart. Journ. Geol. Soc.,' vol. xxvii, p. 285.

[2] Judd, ibid., vol. xxxiv, p. 669.

must necessarily also be of that age. When, however, the Mull plants were described by Edward Forbes in 1851 [1] no more could be said about them than that they might belong to Taxites ?, Filicites ?, Rhamnites ?, Platanites ?, Alnites ?, and that "the general assemblage of leaves, when judged by the present [1851] state of our knowledge of the vegetation of ancient epochs, is decidedly Tertiary, and most probably of that stage of Tertiary termed Miocene." Heer was subsequently unable to definitely claim more than one, and that perhaps the least satisfactory of all, the Taxites,[2] as a Miocene form. We now know that the plants bear at least as strong a resemblance to those of the Cretaceous beds of Dakota as they do to those of any European Miocenes, and much might be said in support of their reference to a late Cretaceous age. But to whatever age it might be possible to assign the Mull Flora, the age of the Antrim Floras would still be a matter of question, for they have nothing in common, except perhaps a Conifer described now for the first time from Mull, and which could not have been taken into account in former comparisons of the Floras. They both, however, bear no small resemblance to certain of the Tertiary Floras of Greenland, whose age I have already demonstrated to be no less open to question.[3] Not only has our knowledge of Cretaceous and Cretaceo-Eocene Floras enormously expanded since their ages were first defined, but we are also gradually becoming aware that the Eocene Floras were far more changing and varied than had been supposed. We no longer believe that all Floras comprising modern and temperate-looking genera, such as the Plane, Hazel, Beech, Alder, Poplar, Willow, Elm, Liquid-ambar, Sassafras, Pine, Redwood, and Swamp Cypress must be Miocene, nor that Floras containing Palms, Proteaceæ, Figs, Aralias, Podocarps, and Araucarias, are the only ones distinctive of the Eocenes.

The time has not yet arrived for entering more deeply into a question which can only be fully discussed when all the plants have been determined; and it would be useless to attempt now either to point out the actual evidence connecting the plants of the Basalts with the Eocene period, or to dwell upon the absolute insufficiency or rather total absence of evidence connecting them with the Miocene. I will now terminate this digression, rendered necessary at this stage of the work by the progress of our researches and the new series of plants that have in consequence to be incorporated, by a brief description of the actual localities whence they are being obtained. They are so far entirely confined in Ireland to the middle zone of the Basalts. The amygdaloids of which this is largely composed are closely similar to those of the Faröes and Iceland, and are probably of the same age. The plants are already known to occur in white clay, in lignite, in clay-iron-ore, nodular iron, and as silicified wood, at several places; and it is generally conceded that the three former varieties of matrix are on or about the same horizon, estimated at some 600 feet from the base and 400 feet from the top of the formation.

Irish bauxite, or hydrate of alumina, is a nearly white aluminous earth which

[1] 'Quart. Journ. Geol. Soc.,' vol. vii, p. 103.

[2] *Sequoia Langsdorfiii*, according to Heer.

[3] See before, p. 3.

adheres to the tongue when dry, and never becomes plastic when wet. It is quarried near Glenarm, and certain beds a little in rear of that town, formerly cut through to reach it, abounded in handsomely preserved plant remains, whose dark colour rendered them conspicuous against their white matrix. It is unfortunate that during the whole progress of the quarrying operations no one, not even the officers of the Geological Survey, who were then on the spot, thought it worth while to collect, so that only a few stray specimens were preserved. I am able, however, through the courtesy of their proprietor and the energy and interest taken in the subject by Mr. Walter Jamieson, to have the mine drained and again rendered accessible, so that I have great hopes that this, by far the most beautiful and best preserved of any Flora included in the Basalts, either of Greenland or elsewhere, may be properly investigated. It seems to be similar to the Ballypalady Flora except that it is far richer in leafy trees. A detailed description will not be possible until the drainage of the mine shall have been accomplished.

The principal deposits of lignite are above the bauxites and sometimes rest upon them. The thickest beds vary from two to five feet in depth and occur at Ballintoy on the coast, about thirty miles distant from Glenarm. They are full of compressed wood, with well-defined structure and belonging to trunks of trees which must in some cases have been of considerable girth. The leaf-bearing portions are very compact, but split readily into laminæ, on the surfaces of which the leaves, fragmentary and much macerated before being imbedded, are faintly defined by their more glistening surfaces. The majority of the leaves contained in them belong to a peculiar triple-nerved form, whose affinities are not yet understood, named *MacClintockia* by Heer, and which is abundant in some of the Greenland shales.[1]

The Iron-ores are widely spread, and occasional minor beds of bole are distributed throughout the formation without any apparent order; but these are merely the result of the surface decomposition of the lava between successive flows. The principal beds are on one horizon, and extend from the coast near the Giant's Causeway to Ballypalady, a spot a few miles south of Ballymena. Opinions differ as to whether the pisolitic ores were formed by confervoid Algæ in shallow lakes, or are the more direct products of the decomposition of Basalt. All the boles that were formerly sub-aërial soils are unfossiliferous unless roots or stems happen to be preserved, which is often the case, while the pisolitic ores and conglomerates, if really lake-deposits, have probably from their nature permitted the plants they may once have contained to go on decaying away after they were embedded. The only fossiliferous iron-ores occur at Ballypalady, about a mile from Templepatrick, and were formerly quarried on each side of the railway. Detailed sections have been published by Portlock, Tate and Holden, Baily, and Kinahan, but the changing operations of the quarryman have made it difficult to exactly reconcile them with the faces now exposed. The beds are laminated clay-iron-ore, fine breccias or conglomerates, and thin seams of lignite irregularly deposited and somewhat twisted, and some twenty-five feet

[1] The best account of the Irish Lignites is that by Mr. William Gray, 'Tenth Annual Report of the Belfast Field Club,' 1872–73, p. 28.

in total thickness, though it is not apparent that their base is exposed. The quarry runs east and west for nearly 200 yards, the direction having been determined by a dyke which forms for some distance its northern face. Plants occur throughout the finer kinds of sediment, though fir-cones sometimes extend to the coarser matrices and are generally more abundant towards the base. They have hitherto been supposed to be lacustrine, but the coarseness and brecciated nature of some of the layers and their irregular bedding seem to indicate, on the contrary, deposition by running and shifting water of very variable volume. The presence of fir-cones and other fruits, associated together with objects, such as Pine-needles and leaves, of such very differing specific gravities, does not, on the other hand, accord with what is usually observed in assemblages of plant remains deposited by moving water. Perhaps the true explanation must be sought in a series of backwaters or isolated pools of sluggish or stagnant water liable to sudden floods or great accessions of volume. They are certainly neither lacustrine nor swamp deposits.

There is still considerable doubt as to the true matrix of the celebrated silicified wood of Lough Neagh, but this is a question with which we are not here materially concerned. The iron-stones with leaf-impressions, which are found on the shores of the same lough, are of more immediate interest, and it would be of some importance to ascertain their real age. I believe them to be *in sitû* in the extensive so-called Pliocene deposits of blue clays and surturbrands, which are stated to occupy an area ten miles in length by four miles in breadth, and to have been bored to a depth of 300 feet without bottom.[1] The leaves seem to differ from those of the other localities, and to be nearer those of existing Beeches, Alders, and Willows. The nodules appear in every way identical with those met with on the Norfolk coast near Bacton at certain states of the tide. On the other hand, the resemblance they bear to nodules brought by Mr. Whymper from Greenland, of much older dates, is no less remarkable. The supposed Pliocene deposits seem to be younger than the period of volcanic activity, as they are quite free from scoriæ and ash, and independent of the Basalts. Their true age, however, is an interesting problem which the plant remains will undoubtedly enable us to solve.

Cupressus[2] Pritchardi, *Goepp.*, sp. Plate XVI, figs. 8 and 9; Plate XVIII, fig. 1, cones only; Plate XIX.

Pinites Pritchardi, *Goeppert.* Foss. Conif., p. 220, 1850.
Cupressites MacHenrii, *Baily.* Quart. Journ. Geol. Soc., vol. xxv, p. 357, pl. xv, fig. 5, 1869.
Cupressoxylon Pritchardi, *Krauss* in *Schimper.* Pal. Vég., vol. ii, p. 376, 1870-72.

Basaltic formation, Ballypalady, County Antrim.

The leaves are very small and scale-like, oval-pointed, imbricated in four rows, either

[1] 'Brit. Assoc. Report.,' 1853, Griffith, p. 43.

[2] See *ante*, p. 25.

two or three of which are visible according to the position in which the branchlet has been embedded, or with the points slightly spreading and falcate.

The foliage is adequately represented by two or three exceptionally fine specimens, and innumerable smaller branchlets. The largest measures seven inches in length, and the principal stem is clothed with relatively long, adpressed, decurrent, scale-like leaves, with points free and acute. The lateral branchlets are much subdivided, branching at angles of about 45°; the ultimate shoots are alternate, rarely exceeding twenty millimètres in length, and have the appearance of very finely plaited cord. The branchlets seem usually to have been shed in segments of about the size represented (Pl. XIX, fig. 4), Figs. 1, 2 (Pl. XIX) being exceptional. The cones are globular or slightly oblong, about fourteen millimètres long and composed of ten hexagonal scales. The scales quit the axis at nearly right angles, are irregular in size and form, with the head having unequal sides and ornamented with wrinkles converging to a nearly central boss or prominence elongated transversely to the axis. Two scales are sometimes soldered together, but the basal ones are not united as in the Bournemouth *C. taxiformis*. The cones occur singly or in clusters, sometimes of six or seven, and are seated on short footstalks five or six millimètres in length, to which they always remain attached. I have not hitherto found a cone attached to a leafy branchlet, but the footstalk is often clothed with scale-like leaves, sufficing to show that the cones and foliage really belong to the same species. The seeds have not yet been observed, owing no doubt to the unfavorable nature of the matrix.

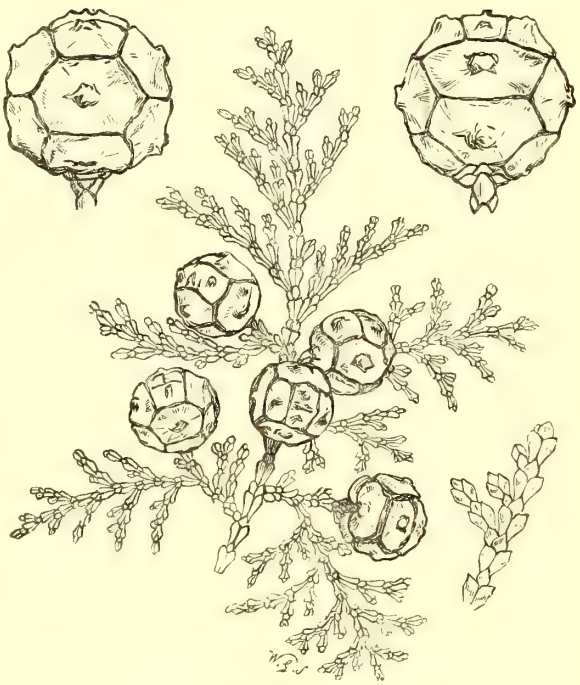


Fig. 33.—*Cupressus obtusa*. (Veitch's 'Manual of the Coniferæ.')

The cones and foliage united, present all the characters of a true Cypress. The foliation of many living species is very similar, but ours agrees in its most minute characters with that of *Cupressus funebris*, an Oriental variety of *C. sempervirens*, and *C. torulosa*. The presence of cones enable us to unite it more definitely with the latter, and to say that the Antrim species was, if not absolutely identical with the magnificent *C. torulosa*, so near it that it would, if living, not be separated specifically or even made a variety, so far as fruit and foliage go. The cones in the living species, as in the fossil, occur in great abundance, either solitary or in clusters, and detach themselves when ripe from the foliage and fall singly, or more rarely, two or more on a stem. The identity of

both these principal organs with those in a living form make it pretty well a matter of certainty that the other organs were also identical, and that the fossil formed a no less majestic tree than the living. If such an induction were not permissible, there would be an end to palæontology. We may, therefore, consider that our fossil Cypress was a tree, stately and erect, towering as straight as an arrow to perhaps a height of 150, and with a girth of a dozen or even a score of feet. We may picture a conical outline such as these trees now possess in their Himalayan habitats, with branches slightly drooping, the branchlets ferny and feathery and of a beautiful greyish green. The Cupressineous wood of Lough Neagh doubtless belonged to this tree, and huge logs of it were formerly found; and we may infer that before petrifaction it must have been as deliciously fragrant as that of *Cupressus torulosa*, held sacred by some tribes through its perfume. This does not prevent the clumps or larger masses which clothe the hills from 4000 to 8000 feet up, from suffering the same fate as the Deodar, where water-transit is available, and large quantities annually reach the Indian markets. A peculiarity about the Irish distribution of *C. Pritchardi* is that it seems confined to the Iron-ores of Ballypaladay, and is absent (unlike *Cryptomeria Sternbergii*) from the bauxites and lignites and from the shales of Mull, telling eloquently that the former was formed nearest the mountain habitats it loved. Its preponderance shows how largely the old Alpine forests of Antrim were composed of it. Mr. Baily's figure conveys an inaccurate idea of the foliage, the leaflets being made to appear subangular instead of oval-acute; and no sufficient specific diagnosis is attached to it. I have restored Goeppert's original name to this splendid and truly representative species from the Irish Tertiaries, since no inconvenience can arise through including the wood with the other organs under the same specific name.[1]

If present elsewhere in Europe, it has been mistaken for *Juniperus* or *Glyptostrobus;* but I am of opinion that Antrim was its southern limit, at least during the Middle and Upper Eocenes. It seems to have been present in some of the more northern Floras, though no satisfactory figures of it occur in Heer's works. Any of the very unsatisfactory fragments figured as *Thuites Ehrenswärdi*, *Th. Meriani*, *Th. Parryanus*, might have been detached from the specimens represented in figures 1 and 2 of Pl. XIX, and Mr. Whymper's Greenland Conifer, determined as *Widdringtonia helvetica*, may probably also belong to it.

Genus—Cryptomeria.[2]

This genus is confined to China and Japan, and now possesses only one species, though many varieties have been produced during the ages it has been under cultivation. The male and female flowers are separate but on the same plant. The cones are solitary or

[1] A careful examination, by Mr. Carruthers, of some twenty prepared sections of different specimens of the wood from Lough Neagh failed to show any variation or new characters, all apparently belonging to one kind of tree.

[2] See *ante* p. 29.

two or three together, without foot-stalks, spherical and terminal, with loose scales fringed at the edges. There are from three to five seeds under each scale, with slight membranous wings. The leaves are in five rows, irregularly four-sided, sickle-shaped, acutely pointed, decurrent, and persistent. The tree is large and evergreen.

CRYPTOMERIA STERNBERGII, *Goeppert*, sp. Plate X, figs. 2, 3, 10—13; Plates XX and XXI.

ARAUCARITES STERNBERGII, *Goeppert* (pars). Ettingshausen, Die Eocäne-Flora des Monte Promina, p. 12, pl. v, 1855.

SEQUOIA STERNBERGI, *Heer*. Flora foss. Arctica, vol. iii, part 3, pl. ii, figs. 1—4, p. 10, 1874, &c.

— DU-NOYERI, *Baily*. Quart. Journ. Geol. Soc., vol. xxv, p. 361, pl. xv, fig. 4, 1869.

Basaltic Formation, Ballypalady and Glenarm, County Antrim; and the Isles of Mull and Canna.

The leaves are spirally arranged, crowded, four to seven millimètres in length, decurrent, and somewhat expanded at the base, quitting the stem at an angle of about 40°, falcate or faintly spathulate, tapering to the extremity, very variable, sometimes apparently imbricate, more often needle-like.[1] The branchlets, densely clothed with leaves, are irregular or alternate, fork copiously at acute angles, presenting a somewhat tufted growth, and were shed in short lengths separately from the cones. The cones sub-globose, and averaging from fifteen to twenty millimètres in diameter, are composed of numerous persistent, loose, apparently sub-ligneous scales, which all diverge from a point near the base of the cone and are clothed externally with spiny, bract-like appendages.

The cones were shed after the escape of the seed, with the scales gaping and permitting the matrix to enter between them. When found they almost invariably split down the centre, leaving half on each face of the stone so as to present a longitudinal section (Pl. XX, figs. 8, 9, 13). Only the inner faces of the scales are thus exposed, and these are seen to be striated, with roughly-fringed edges. When the impression of the exterior of the cone has been bared with a needle, six or eight spirally-arranged scales become visible. These are seen to be quite constricted at the base, then gradually widening until they fan out suddenly to a diameter of six or seven millimètres, after which they again contract so as to terminate in the form of a slightly-pointed arch. They are crossed exteriorly at the widest part by a deep but narrow scar, in the centre of which is a pit marking the position of a central spine or bract which has projected into the matrix at right angles. The entire scale is grooved or furrowed parallel to its lateral margins, and deeply cut or fringed along the superior one, the segments of this fringe being often slightly subdivided.

[1] The leaves appear shorter and blunter when pressed against the stem than in profile, owing to the extremities breaking away with the matrix.

The axis does not penetrate the cone, and all the scales are directed upward and diverge at acute angles from a single point, but it is prolonged inferiorly into a sort of footstalk, which occasionally seems obscurely scarred.

In no specimen known to me from Ballypalady, out of nearly 100, are cones attached to the foliage, though they are always found in singular proximity (Pl. XX, figs. 3, 4, 6, 8, 13). The cones bear a strong resemblance to those of *Thuya*, and, if they could be united to the imbricated Cypress foliage, such species as *Th. gigantea* and *Th. orientalis* would be apparently reproduced. But if such were the case, the Cypress foliage would have to do duty for two sets of cones belonging to different genera, while the lax foliage would have to be assigned to some Conifer with fruit so inconspicuous as to have escaped notice, such as some of the *Dacrydia* or *Juniper recurva*. The cones, however, are composed of many more scales than are met with in *Thuya*, and for many reasons I think we may dismiss such a determination and accept the view that the cones and foliage described are actually the product of the same plant. In this case their reference to *Thuya* becomes impossible, for though a few *Thuyæ* and *Cupressi* occasionally bear a lax foliage, it is either of different type or confined to the seedling stage of growth.[1] Our choice is in fact practically narrowed to *Cryptomeria*.[2]

Fig. 34.—*Cryptomeria japonica* (Veitch's 'Manual of the Coniferæ').

In comparing our cones with those of the existing *Cryptomeria* several important differences are observable. The base of the cone is much broader in the living species, the form more pyramidal, the basal scales directed downwards, and the fringed margin more regular and deeply indented. On roasting some of the cones in plaster, so as to reproduce to some extent the condition of the fossils, the resemblance is greatly increased, for the umbonal spine leaves a similarly cleanly-cut transverse scar in nearly the same position across the scale, which is also seen to be similarly furrowed and of the same outline, except that the scar in the fossil is a little lower down. The foliage is shorter and denser, and inclined in places to become more imbricated than in *C. japonica*.

The divergence between the fossil and its living representative is more accentuated

[1] *Th. occidentalis, Cupressus nutkaensis, C. funebris, C. fastigiata, Widdringtonia cupressoides,* and *W. juniperoides,* occasionally bear foliage of both kinds.

[2] Since the above was in type, foliage *with cones attached* from Glenarm have amply confirmed the determination.

than is usually the case with the Coniferæ of so late an age as the Eocene. The reason of this exceptional differentiation may be looked for, it appears to me, in the fact that the single existing species of *Cryptomeria* has been cultivated unremittingly in Japan, perhaps for many centuries, with a view to produce sports and varieties, which were held in religious esteem. One well-known variety in cultivation, *C. elegans*, has foliage which departs widely from the original type, while another, *C. araucaroides*, approaches the fossil closely. The *Cryptomeria* of our gardens is a variety introduced by Mr. Fortune from seed gathered in the north of China and the Isle of Chousan, and has leaves nearly twice as long and more closely pressed to the branches than the true stock of Japan. Plants transplanted to hills in Java, under similar conditions of soil and temperature, have rapidly degenerated, and approach the fossil type of foliage. The excessive fimbriation or bractation, which masks the structure of the cones, has probably been increased by artificial means, for apparently starved cones in England much more nearly approach the fossil, and the frequent tendency of the axes to penetrate through them and to foliate is additional evidence that they have become somewhat abnormal under cultivation. All the genera of the Taxodieæ have been met with in some abundance in Cretaceous and Tertiary rocks except *Cryptomeria*, and it does not seem unreasonable to suppose that the changes brought about by ages of cultivation have rendered its recognition difficult.

There can thus be little doubt that our Conifer is the wild stock of the considerably-modified *Cryptomeria* of Japan, and that this then bore a greater resemblance to the nearly-allied *Taxodium heterophyllum* than it does at present. It still loves a basaltic and humid soil, and under such conditions forms vast forests; at least a tenth part of those which clothe the three principal isles of Japan, from 500 to 1200 feet above the sea, being formed of this tree. Its fine pyramidal crests and deep green contrast with the Laurels and Bamboos, and give a peculiar and characteristic aspect to the wooded regions of Eastern and Southern Japan. In more western and northern latitudes, where leafy evergreens are rarer, it combines with the Abietineæ and Cupressineæ and evergreen Oaks to impart a freshness to the forest vegetation during winter.[1] It reaches a height of 130 feet, and occasionally rivals its companion Cypress in girth, and is a majestic and graceful tree, strongly recalling *Araucaria Cunninghami*.

The fruits of this species exceed in abundance those of the associated *Cupressus*, and indeed all other fossils at Ballypalady. Unlike the Cypress, it abounds under the bauxite, as we might expect on the supposition that these contain the spoils of lower land, for it now ranges to within 500 feet of the sea-level, while the Cypress is a more purely Alpine tree. It, or something like it, has also been found in Mull and Canna, and seems everywhere present among the Arctic Floras described by Heer, though referred to the genus *Sequoia* in his works. I have little hesitation in also referring the so-called *Sequoia Sternbergii* of Monte Promina to it, as I have specimens of foliage which are not only

[1] Siebold, 'Flora Japonica,' 1835.

identical, but associated with the scale of a similar cone; and it may therefore possibly have had a considerable range in Europe. The foliage and cones are easily distinguishable from any others in the British Tertiaries.

The variety recently obtained from Glenarm approaches far more closely to the ordinary and more luxuriant type at present existing in Japan.[1]

The iron-ore or bauxite mine of Libbert, whence they were obtained, is situated at about 700 feet above the sea-level and nearly a mile in rear of Glenarm. No outcrop of the strata is visible in its vicinity, except an occasional patch of basalt on the roadside; but its position must be some 400 or 500 feet above the junction with the Chalk, and therefore probably at about the same horizon as the plant-bed at Ballypalady. The shaft or adit is horizontal, and the work of draining it, though long and laborious, was not one of serious difficulty. For the first 20 or 30 feet it pierces Boulder-clay, and about a dozen feet farther in, a compact, almost white, sandy clay is reached, in which the plant remains occur. The base of the adit is almost indurated micaceous sand of unknown thickness, said by the miners to repose on lithomarge. As the beds rise slightly with the slope of the hill, the rest of their thickness can be studied as they are successively cut through. The "leaf-bed" is more compact and clayey, and for about a foot in thickness contains well-preserved plant impressions. It passes upward into imperfectly laminated clayey sand, stained grey with vegetable matter, and enclosing limbs and trunks of trees. The "leaf-bed" seems to be confined to an area of not more than two square yards, but the darker clayey sand extends far into the mine, and contains less distinct impressions at those points where it has been examined. Overlying this is a singular conglomerate made up of rounded pebbles of reddish indurated clay embedded in a hard gritty paste. The surfaces of these pebbles are polished and darkened by squeezing and pressure, and it is difficult to realise at first that some of them are not flints. There are also coarse quartz grits cemented together by a clayey matrix. The bauxite, a ferruginous hydrate of alumina, overlies these, and is said to be about 30 feet above the "leaf-bed," and also contains masses of lignite and trunks of trees. Deeper in the mine it becomes blotched with red and gradually passes into the iron-ore, by which it also is overlain. The deposit, like those of Ballypalady and Ardtun Head, is fluviatile, and marks the former bed of a river.

The leaf-bed, though rich in specimens is poor in species. There are but two prevailing varieties of leafy trees, the commonest being a large and deeply indented leaf, such as might be borne by a large-leaved oak or maple; and the other a long parallel-

[1] When the descriptions of the Coniferæ were first undertaken, none of the materials for the plates illustrating the Basaltic Flora of Ireland had been brought to light. The method of publication in yearly parts permits revision and addition while the work is in progress, and the latest interval has been utilised in repeated visits to Antrim, during which the Ballypalady specimens, occupying plates xv—xx, were obtained and figured. A further slight delay has also enabled me to insert an account of the fine specimens just obtained from Glenarm. The plant-beds had been deep under water at the time of my former visits.

veined leaf, known as *MacClintockia*, belonging to a shrub perhaps which might have formed an evergreen undergrowth. With these, and lying in every direction, are tufts of *Cryptomeria*.

I ventured previously to assign the disjointed fragments of foliage and the small cones so abundant at Ballypalady to this genus, although I had not seen them actually attached together. Here we have, however, at Glenarm, branchlets of most luxuriant growth, with cones actually seated upon them (Pl. XXI), and possessing every characteristic of *Cryptomeria*.

The leaflets are larger and more crowded than those of Ballypalady, but not quite so large as in the existing species, woodcut, fig. 34. The branches were so densely tufted that their branchlets are compressed four or five deep upon each other, and they present the peculiar parallelism and acute angles of divergence of the existing species. The foliage is smaller than that of *Araucaria Goepperti*, Pl. XI, fig. 1, and does not present any trace of seasonal variation. The cones are globular, usually solitary, but sometimes two are attached to the same branchlet, which is thickened to support them. They are rather less than an inch in diameter, composed of numerous fringed scales springing from a short axis, and seemingly identical in structure with living examples. The tree must in fact have been similar in appearance and habit to the most luxuriant of the existing types; and it is quite apparent from this, no less than from its great abundance, that the station it occupied was a highly favorable one.

It might be questioned whether it should remain united specifically with the relatively starved variety of Ballypalady, but the fact that the living species varies in at least an equal degree, according to the nature of its station, seems to preclude any separation. It does not appear that any other Conifers accompany it in the beds at Glenarm.

Genus—Taxus.[1]

Taxus Swanstoni, sp. nov. Plate X, figs. 4, *a* and *b*, and 5.

Basaltic Formation, Ballypalady, County Antrim.

Only simple branchlets of this rare fossil have hitherto been met with. The best specimen measures seventy-five millimètres in length, but its base appears rather broken than articulated. It is clothed only for the first half of its length with short, very obtusely pointed, undeveloped, spirally disposed, scale-like leaves, some of which become expanded higher up into distichous leaflets of a yew-like aspect. These are narrow, linear, variable in size up to fourteen millimètres in length, opposite or alternate, parallel-sided, obtusely pointed, shortly decurrent, and with distinct mid-rib. A few seem adpressed to the stem, but the great majority quit it at almost a right angle. The terminal leaflets are very small, and the apex of the branch is consequently somewhat truncated.

[1] See *ante*, p. 43.

The short and obtusely pointed undeveloped leaflets, and the obtuse angles formed by those which are expanded, and their blunted apices, serve to distinguish it from other British species, and especially from that described as *Sequoia Langsdorfii* from Mull. These characters agree much more closely with those of the Yew than with any other Conifer, and particularly with some forms of *Taxus cuspidata* of Japan in the Kew Herbarium, and *T. baccata Maderensis* of the Canaries. *T. cuspidata* is a hardy species found on the Island of Jezo, and the Madeira Yew is almost extinct.

I have named the fossil in compliment to my friend Mr. William Swanston, F.G.S., and Hon. Secretary of the Belfast Naturalists' Field Club, to whom I am indebted for much kindness and assistance.

Some of the Arctic specimens determined as *Sequoia Langsdorfii*, *Taxites validus*, and *T. Olriki*, greatly resemble it, and an actual comparison may prove their identity.

ATHROTAXIS COUTTSIÆ, *Heer*, sp. (See page 36.) Plate VI, figs. 1—9; Plate X, figs. 6—9.

SEQUOIA COUTTSIÆ, *Heer* (pars: Hempstead). Quart. Journ. Geol. Soc., vol. xviii, p. 369, pl. xviii, 1862.

The cones are woody, globular, about thirteen millimètres in diameter, persistent after shedding seed, and composed of about twenty-four imbricated scales, arranged spirally on a very short axis. The scales are persistent, wedge-shape, contracted and stipitate at base, thickened at the apex; the heads are lozenge-shaped to pentagonal, wider, seven millimètres, than high, five millimètres, convex exteriorly, much hollowed interiorly to receive the seeds, with a more or less lozenge-shaped scar in centre. The scales become much smaller towards the base. Seeds of the same species are figured by Heer from Hempstead, and are small, curved, and winged laterally. The leaves are very small, thick in texture, closely adpressed to the branches, imbricated, spirally arranged, ovate, pointed, sometimes falcate, obscurely keeled on the back, concave on the face, entirely adherent at the base.

The discovery late last autumn of very perfect and uncompressed specimens of this Conifer at Hordwell revealed the fact that the scales of the cone are overlapping or imbricate as in *Athrotaxis*, and not at right angles to the axis as in *Sequoia*. In describing *Sequoia Couttsiæ* in the present work (*ante*, p. 38) I felt the unsatisfactory nature of the determination, remarking that the remains existing did "not conclusively establish the accuracy of its reference to *Sequoia*," and that the evidently swampy station it flourished in was at variance with the habits of either existing species. The leaves also are far more slender and delicate than those of the existing *S. gigantea*, and do not suggest that they could have belonged to a tree of robust habit and colossal size. I have no hesitation whatever in uniting the Hempstead specimens with this species, but those from Bovey-Tracey described by Heer have disappeared, and the figures give no

indication of the position of the scales on the axis, and their formation seems somewhat different. I do not therefore at present feel that the material would justify the transfer of the Bovey specimens to another genus, especially as their reference to *Sequoia* has been very widely accepted in text-books, and the supposed presence of a representative of the giant trees of California made the basis of much speculation and inference. I think it highly probable, however, that the species may be found not to be a true *Sequoia*, and the danger is very apparent of giving the reins to the imagination and picturing the slopes round the ancient Bovey water as clothed with woods composed "mainly of a huge coniferous tree (*Sequoia Couttsiæ*), whose figure resembled in all probability its highly admired cousin, the *Sequoia* (*Wellingtonia*) *gigantea*, Lindl., of California."[1] If the supposed *Wellingtonia* should prove to be but a marsh-loving plant, as the supposed tree-ferns of "imposing grandeur" have proved to be but humble Osmundas, how completely at variance must the actual appearance of the vegetation have been to that so graphically described in Heer and Pengelly's work.

The Hordwell specimens are indistinguishable from *Athrotaxis cupressoides* of Tasmania, "a small erect tree, from twenty to thirty feet high, much branched, and with numerous branchlets, which are slender, spreading or pendulous, and cylindrical."[2] "It is found at Lake St. Claire and along Pine River, in Tasmania, and is tolerably hardy." The *Athrotaxides* form a small genus, allied to *Sequoia*, now entirely confined to Tasmania. The fact that the species are little known and are still rare in herbaria has no doubt prevented hitherto the reference of any fossils to the genus. The occurrence of two undoubted and almost unaltered species in our Eocene is not a little singular, and of great significance.

Incertæ Sedis.

Two other Coniferæ, at least, are known to me from British Eocenes, but both too imperfectly to even guess the genera to which they might belong. They are both from the Lower Eocene, respecting whose Floras our knowledge is so scanty, that it would be of great interest to ascertain more concerning them. The first is from Reading, and is a Conifer not dissimilar in appearance and habit to the Bournemouth specimen of *Taxodium eocænum* figured on Plate VII, fig. 3. The second is from the Park-hill cutting at Croydon, and is like, but far more slender than, the *Athrotaxis* just described, from Hordwell. A fossil completely identical with it is named *Glyptostrobus gracillimus* by Lesquereux, from the Cretaceous of Dakota. It is worth while calling especial attention to this fact, as so many of our Lower-Eocene plants have representatives in that Flora. A few specimens from the Eocene or Oligocene of Central Europe, referred generally to *Widdringtonia*, almost rival it in delicacy; but, so far as I am aware, no existing Conifer has such slender foliage.

[1] "Flora of Bovey," 'Phil. Trans.,' 1862. [2] Gordon's 'Pinetum,' p. 47, 1880.

Order—GNETACEÆ.

The Gnetaceæ form a very distinct order of Gymnosperms. Their fruit is ovate and drupaceous, or compressed and membranaceous, and the flowers are arranged in catkins. They are characterised by their stems being jointed at every node and their ligneous tissue being marked by circular discs. The three known genera, *Welwitschia*, *Ephedra*, and *Gnetum*, are very dissimilar in appearance. While retaining the peculiarities of Gymnosperms they present a plain transition to true Exogens.

Welwitschia is a most singular and abnormal plant inhabiting the arid regions of South-west Africa, between the 14th and 23rd degrees of south latitude.

Gnetum inhabits the tropics of Asia and America, except an African and a Fijian species. There are about fifteen species known, most of which possess large ovate or lanceolate, dark, coriaceous leaves, with simple margin and anastomosing secondary veins. Although some Eocene leaves are not dissimilar, the inflorescence, the fruit, and stems are so peculiar and apparently so easily preserved, that in their complete absence from all known fossil-bearing rocks, we must for the present conclude that no *Gnetum* formed part of the European Tertiary Flora. The *Ephedræ*, however, were widely spread in at least the European Eocenes.

Genus—Ephedra, *Linn.*

The flowers are unisexual, most often dicœcious. The fruit is drupaceous, oblong, indehiscent, succulent, with a hardened interior, and formed of two carpels with a single seed in each. The branches are slender, nodose, and jointed, erect or pendulous, and the leaves very small and scale-like. Some thirty species are known. They are erect or scandent, apparently leafless shrubs, copiously branching and abounding on the sandy sea-shores of Eastern Europe, North Africa, temperate and sub-tropical Asia, and extra-tropical America, from Chili to California. They closely resemble *Casuarinæ*, but a critical examination enables their stems to be distinguished.

Their peculiar jointed and striated stems can be picked out in abundance from the innumerable masses of pyritised twigs left by the tide at Sheppey. I have also met with a fruit, apparently a thin oval shell of the size of a small nutmeg kernel, labelled "Gnetum," but probably intended for *Ephedra*, in the Bowerbank Collection from Sheppey; but it is now in fragments, and I am unable to restore it. There is no doubt, however, that a species of *Ephedra* similar to that now living on the shores of the Mediterranean formed part of the Sheppey fossil Flora.

I have also come across a stone perforated with twigs which have all the characters of *Ephedra*, on the shore of Lough Neagh.

Species have been described by Unger, from Sotzka; by Heer, from Switzerland; and by Ettingshausen, from Häring.

indication of the position of the scales on the axis, and their formation seems somewhat different. I do not therefore at present feel that the material would justify the transfer of the Bovey specimens to another genus, especially as their reference to *Sequoia* has been very widely accepted in text-books, and the supposed presence of a representative of the giant trees of California made the basis of much speculation and inference. I think it almost certain, however, that the species may be found not to be a true *Sequoia;* and the danger is very apparent of giving the reins to the imagination and picturing the slopes round the ancient Bovey water as clothed with woods composed "mainly of a huge coniferous tree (*Sequoia Couttsiæ*), whose figure resembled in all probability its highly admired cousin, the *Sequoia* (*Wellingtonia*) *gigantea*, Lindl., of California." [1] If the supposed *Wellingtonia* should prove to be but a marsh-loving plant, as the supposed tree-ferns of "imposing grandeur" have proved to be but humble Osmundas, how completely at variance must the actual appearance of the vegetation have been to that so graphically described in Heer and Pengelly's work.

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The specimens obtained from the Bembridge Marls, Gurnet Bay, occur above the "Insect Bed," and unlike those previously described are *in intaglio*. They prove, though relatively rare, that the species maintained its ground between the Hordwell and Hempstead horizons; from both of these it had previously been obtained. They are figured Plate XXII, fig. 10; Plate XXVII, figs. 4, 4, *a*.

Sequoia Shrubsolei, sp. nov.

London Clay; Sheppey.

The cone is ovate, 37 millimètres in length; 20 millimètres in its widest diameter, and about one third less when measured from back to front or at right angles to the plane shown in the figure. Before compression, therefore, it must have been of a cylindrical form, shaped like a cocoon, and about twice as wide as high, and rather obtuse at both ends. It is composed of about 40 scales, lozenge-shaped, or imperfectly hexagonal, measuring 10 millimètres across and 8 in height, becoming smaller towards

[1] "Flora of Bovey," 'Phil. Trans.,' 1862. [2] Gordon's 'Pinetum,' p. 47, 1880.

the apex of the cone, and very slightly diminishing towards its base: they are sunken in the middle, and have been considerably abraded. The cone was embedded before the scales had gaped, and still adheres to a stout footstalk 7 millimètres across.

Fig. 35.—*Sequoia Shrubsolei.* London Clay; Isle of Sheppey.

These characters agree well with *Sequoia*, and in all probability the fossil belonged to a species of the *S. gigantea* type (Fig. 12, p. 33). The fact that the scales are tightly closed, are preserved in pyrites instead of lignite, that they had undergone compression, and that the petiole had a relative stoutness, all favour the assumption that the cone had not reached maturity when detached from the tree. There is no other existing genus to which it could possibly be referred except *Pinus*.

It reached me among a parcel of fruits sent from Sheerness by Mr. W. H. Shrubsole, F.G.S., and is, so far as I know, a unique specimen.

Taxodium europæum,[1] *Brongt.* Plate XXIV.

Reading Beds; Reading.

The species was fully described at page 30 of this memoir. The beautiful specimen figured (Plate XXIV) and another from below the Mottled Clay at Reading, were obtained this summer, and show that a species, once claimed to be typical of the Miocene, flourished in our area long before ever the Palms and other tropical plants of the London Clay of Sheppey, and of the Lower Bagshot of Alum Bay, had become introduced. The stratigraphical evidence as to their age is fortunately so good, the London Clay actually capping the Mottled Clay in another part of the quarry, that it is beyond cavil. The whole of the assemblage of plants, which are of remarkably temperate aspect, must, when they become better known, force every one to admit that preconceived ideas as to what are Eocene and what Miocene plants must be banished, and the entire evidence sifted afresh.

The imbricated and distichous foliage are present on the same branches in both the figured and an unfigured specimen. Fragments of Pine-needles, which afford no sufficient material for specific description, accompany it, together with a flower[2] or fruit and dicotyledonous leaves. The matrix is a clay of a pale French-grey colour, very friable, but with perfectly distinct impressions of the vegetable remains, and separated from the overlying Mottled Clay by a few feet of clean white sand. The discovery carries back

[1] See *ante*, p. 30.

[2] Saporta is inclined to believe that this may be a detached cone of a Callitris or Widdringtonia, such as are met with commonly in the gypsum of Aix. He also remarks upon the resemblance of the Glyptostrobus to an extinct Eocene Sequoia described by himself.

the first appearance of the species a very long way, for none older than the Middle Bagshot were previously known. *Anemia subcretacea*, a Fern, is also associated with it both at Bournemouth and Reading.

Specimens have been found in the Woolwich Beds of the Park-Hill cutting at Croydon, resembling *Athrotaxis Couttsiæ*, though even more slender, but it is probable that they may have belonged to the same species as this from Reading.

Doliostrobus Sternbergii, *Goeppert*, sp. Plates XXII and XXIII.

Araucarites Sternbergii, *Goeppert* (pars).		Ettingshausen, Die Tertiäre Flora von Häring in Tirol, p. 36, pls. vii and viii, 1853.
Sequoia	—	*Heer.* Urw. d. Schweiz, p. 310, 1864, and all later works.
Doliostrobus	—	*Marion*, Comptes rendus de l'Acad. des Sciences, 1884.

The Bembridge Marls; Gurnet Bay, Isle of Wight.

The leaves are spirally arranged, awl-shape or falcate, rigid, sharply pointed, keeled dorsally, grooved on their inner face; they are very short near the bases of the branchlets and reach to an extreme length of 9 millimètres, or 13 mm. if the decurrent base be included. Stouter branchlets (figs. 1 and 4, Plate XXII) are clothed with denser and more scale-like leaves. The branchlets seem relatively long and slender, as if the habit of the tree had been lax; and they fork irregularly, but not copiously, at a mean angle of 45°; the terminal shoots being long and simple. Part of a branch (fig. 12) is marked with the inlaid scars common to many of the Coniferæ, resembling scale-armour, the diameter of the scales being about 3 mm., their edges raised, and centres depressed, showing that the branches must have been clothed with broad-based spinous leaves as in the existing needle-leaved *Araucariæ*. There are unfortunately no traces of the fruiting organs among the numerous specimens I have examined, with the single exception of the detached scale occurring on the specimen, fig. 5, Plate XXII.[1] It is slightly curled and with thin margins, widest near the apex, which is acuminate and thickened, tapering to the base, 7 mm. in width and about the same in height.

There is thus little beyond the foliage to help us to the nature of the plant, and it is hardly necessary to state that no botanist would undertake the determination of any living Conifer, presented to him for the first time, on such material. The palæontologist has, however, to accept such specimens as are procurable, and to

[1] Mr. A'Court Smith, who collected them, writes that there were a number of "round discs," which he chipped away in reducing the stones. He adds that their absence may also probably be due to his having failed to look out for them or to recognise their nature.

supply by inference that of which he lacks direct proof. That many have abused this privilege, and come to heedless and unjustifiable determinations of fossil plants, is but too well known; but when their determination can be based on consistent reasoning they should not be set aside too summarily, but accepted with due regard for what they may be worth.

Foliage of this character is not distinctive of any particular genus, or even tribe of Coniferæ, but is met with in *Sequoia*, *Cryptomeria*, *Athrotaxis*, *Araucaria*, and *Dacrydium*, as well as in many extinct genera. In the present instance, it appears to have fallen into river-water that flowed sluggishly, for it abounded in molluscous, and sometimes in insect life, while seeds, twigs, and other objects with differing powers of flotation were embedded together in an oozy sediment. If cones had been adhering to the branches when they fell, they must, under such conditions, have been embedded together. With regard to *Cryptomeria*, Mr. Cossart writes, in reply to my inquiry, that the mature cones are most difficult to detach, and that they remain united to the branchlets that have been shed until these become half rotten. We have also seen them attached in the fossil state (see Plate XXI). I am not aware whether the cones of the Mammoth Tree are shed separately from the foliage, but they have usually been found associated together in the fossil state. *Sequoia* cones, moreover, could not have escaped a collector's notice had they been present in numbers at all proportioned to the foliage. We have seen cones and foliage associated in two species of fossil *Athrotaxis*, and their complete absence in this case almost compels us therefore to exclude all these Taxodieæ from our comparisons. It cannot be assimilated to any existing species of Juniper or Dacrydium, and in no case in fact does the foliage of any berry-producing Conifer resemble it at all closely. We must therefore look for it among those Coniferæ the axes of whose cones remain permanently fixed on the trees, unless accidentally removed, while their deciduous scales and seeds are scattered afar by the winds.

Dr. Marion, of Marseilles, has met with the fac-simile of our fossil in great abundance in the Oligocene of the Tertiary basin of Alais, Gard, between the horizon of *Paloplotherium minus* and the Sandstones with *Anthracotherium*, or as nearly as possible on the same horizon as the Bembridge Marls at Gurnet Bay. The branches of this Conifer are scattered in profusion over the flags of a certain bed at Ceylas, almost to the exclusion of other plant impressions. They are often of large size, and seem to have been shed and not broken from the tree. Dr. Marion describes, in addition to the ordinary falcate leaves, branches clothed with longer and straighter needles scarcely curved at their extremities, the two varieties being always associated together.[1] Scattered over some of

[1] "À côté du type ordinaire, on observe des branches dont les appendices prennent, en s'allongeant, la forme en aiguille droite ou à peine recourbée à l'extrémité. Ces deux sortes de rameaux sont tonjours associées; je ne pense pas qu'elles indiquent deux espèces distinctes," l. c., p. 2. A more detailed description of *Doliostrobus* by the same author is in the press. I met with a fragment some years since in the Bembridge Marls bearing somewhat similar needles to those described, and referred to it at p. 59, pl. xiii, fig. 7.

the slabs are numbers of detached scales very variable in form, more elongate, mucronate, and striate, but in other respects resembling ours (fig. 5, Plate XXII). The cones to which they belonged were terminal and attained a length of 4 centimètres. The scales and seeds were shed when ripe, and the axis remained firmly attached to the branch. Dr. Marion has obtained specimens, not only of the axis wholly and partially stripped, but of entire cones accidentally detached before fully mature. The seeds were free and winged on one side only, precisely as in Agathis.

Fig. 36.—Slab comprising the bare axis of a cone, some loose scales, and a seed; Ceylas. From a drawing communicated by Dr. Marion.

In this, as in other instances, our own insufficient data have been supplemented by more ample material from other countries. The foliage from the Isle of Wight, identified by careful comparison, not of drawings only but of actual specimens, with foliage from the same horizon in France, has enabled us to determine the true nature of the plant to which it belonged with almost as much precision as if the fruiting organs had also been found at Gurnet Bay; thus the inference we should probably have come to independently, is verified. The French deposits were lacustrine, and everything that fell on the water in due time sank and became mingled together. In the moving water, which deposited the Bembridge and Hempstead muds, we can only suppose that the light and dry scales and seeds, though shed in profusion, were carried far away by the stream, however sluggish, or stranded on adjacent shores by the breeze.

Though we may feel confidence in the identification of this species with the French form, it is not so certain when comparison is made farther afield. A similar, but far more robust form of foliage has been noticed from the much older beds of Bournemouth, and identified with *Araucaria Cunninghami*, though a distinctive name was retained for the fossil (Plate XII). We have also foliage closely resembling it in *Cryptomeria Sternbergii* (Plate XXI), though the former can be distinguished by its larger and less tufted appearance and wider angles of divergence, and in *Athrotaxis subulata* (Plate XI).

It is impossible, however, to attempt to apportion the published drawings and descriptions of similar foliage from other Tertiary deposits of Europe, often of unknown age, to these four species. The cone from Häring, originally figured by Sternberg and

by Goeppert, already referred to (p. 57), is oval and elongated and clothed with bracts, and appears more like that of *Araucaria* than of *Doliostrobus*. A cone from the same locality sent to me by Ettingshausen (Fig. 37) is smaller and round, and agrees exactly with those described by Marion. Both kinds of foliage, as well as detached scales, are also met with, and there can be no reasonable doubt that the same or a closely similar species of *Doliostrobus* occurs at Häring at least. Marion informs me that Heer had accepted his conclusions, although he still maintained that the second cone from Chiavon[1] belonged to a different genus. I do not see at present any reason for modifying my former views regarding it, and leave it and the associated foliage, together with that from Bournemouth, in *Araucaria*. *Doliostrobus* is undoubtedly a very ancient form, and it may be a descendant of *Pachyphyllum* as surmised by Marion, as, indeed, may also be our Sheppey *Athrotaxis*. The genus is also present in the Upper Cretaceous of Patoot, for scales described as *Dammara* are associated with foliage called *Sequoia*.[2] There need be no difficulty in admitting that *Araucaria* grew contemporaneously with it in Europe, as the former has actually been traced in France as high as the Upper Senonian.

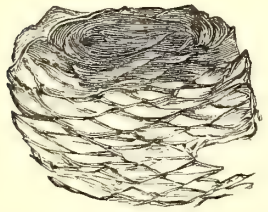

Fig. 37.—Cone of *Doliostrobus Sternbergii*, from Häring.

Had the fossil been a living plant, it would probably have been placed in *Agathis* notwithstanding that no similar foliage had previously been met with in that genus; for we find in *Araucaria* that a species is not excluded because the scales are persistent. As at present defined, however, *Agathis* is characterised by the persistence of its scales, and a fossil species with deciduous scales cannot therefore be included in it.

All the specimens have been collected by Mr. E. A'Court Smith, and they number at least thirty or forty. He writes that they are found from the very base of the Bembridge Marls upwards, almost wherever vegetable remains occur; and specimens I have seen are in matrices of all shades of colour, red, yellow, grey, white, and fawn. The finest occur in septarian concretions, of an ochreous brown externally and pale fawn colour inside, with an extremely fine grain. The septaria are irregularly scattered, from half a foot to two feet in length, with a somewhat conchoidal and very uncertain fracture. The branchlets occur on the exterior as well as in the interior, being best preserved in the latter case. The leaves and stems are in a shrunken carbonised state in hollow cavities, which seem to be exact moulds of the Conifer as it was when first embedded. The stone is often stained for a short distance, a ferruginous brown margining the contour of the mould. The branches are generally slightly compressed horizontally, but sometimes lie vertically squeezed along the cracks. The origin of these blocks which seem to have segregated round the vegetable remains presents an interesting problem. It is clear that they became cracked or fissured while still soft, the lines of fissure following in two cases the thickest stems, and that the compression

[1] See p. 57.

[2] 'Flora Arctica,' vol. vii, pl. liii.

was greater laterally than vertically. The remains of the Conifer are occasionally associated with reedy plants, but are more often found almost unmixed with other vegetation.

PODOCARPUS CAMPBELLI, sp. nov. Plate XXVI.

Basaltic Formation ; Ardtun Head, Isle of Mull.

The leaves are linear-lanceolate, straight or slightly curved, tapering gradually from near the base to a sharp apex, constricted at the base, slightly twisted at the point of attachment, and decurrent as in all distichous Conifers. Their extreme length does not exceed 7 centimètres and breadth 7 millimètres. The mid-rib is distinct, but not salient. There is no trace of secondary ribs, but the whole surface has a finely striate and silky texture. The leaf was leathery and the epidermis dense, with the peculiar loosely-fitting appearance seen in some recent Podocarps, such as *P. neriifolia*. Its thickness and the peculiarity of its structure is revealed where one, and even two distinct layers of tissue have peeled off without injury to the contour of the leaf. The margins, as in all dense and leathery leaves, are particularly well-defined, and were, perhaps, very slightly reflected or curled, as in some living species. The very thin outer epidermis is of a pale vandyke-brown, but when this is stript, the substance of the leaf exposed underneath is warm drab in colour. The specimen, Plate XXVI, fig. 3, shows a longitudinal stripe of richer brown on each side of the mid-rib. The leaves were generally shed singly, and are found scattered on the surfaces of the stone as in fig. 1, where the rupture is seen to have been transverse, leaving the detached leaf without petiole, and with a constricted and truncated base. More rarely they fell still attached to the branchlets, as in figs. 2 and 3, when they are seen to have been sparsely and roughly arranged or pressed into two rows, though somewhat irregularly, being neither opposite nor alternate, and generally set at almost right-angles to the stem. It seems that this irregular spacing was produced through some of the leaves never becoming developed beyond the condition of closely adherent scales, as in the recent *P. neriifolia*, especially when individual leaves were large. The branchlets were short, truncated at the apex, with each year's growth marked off by an encircling scar or cicatrix, giving the stem externally a jointed appearance, common to almost all the living species of Podocarp belonging to the same group. The cicatrix is superficial, and leaves no mark of its presence in the interior of the wood, so that the branchlets do not always break up where they occur. The leaf-scars left on the stem are very ill defined, and the older bark merely looks stringy. The terminal bud (fig. 2) is relatively small. A complete shoot with only three leaves is represented on fig. 1. Those on fig. 3 are unusually small, and I should say from an examination of the dried specimens in the Kew Herbarium, that the

leaves were in this instance thin and not fully developed, for the same wavines s discernible in the right-hand leaves of fig. 3 is visible in recent leaves pressed under such conditions.

As remarked by Prof. Olliver, who at once pronounced them to be Podocarps,[1] even were the specimens living it would not be possible to assign them with certainty to any particular species. There are in fact more than a dozen living Podocarps with very similar foliage, distributed in a great belt extending from Venezuela to Chili, the Cape and Tropical Africa, through Hindustan to Japan, and down to the Fiji Isles, New Caledonia, and Queensland. In nearly all these, the leaves, it is true, are usually arranged in whorls and are more or less tufted, and they also taper more to the base and possess longer foot-stalks; but in some of these species the leaves seem occasionally to revert to the distichous arrangement, and it is therefore not easy to say definitely that the fossil represents any one species to the exclusion of others. The most perfect resemblance is, perhaps, to be found in one of the specimens of *P. falcata*, R. Brown, at Kew, in which the leaves are almost sessile, broadest near the base, and in two rows. This is a native of the Cape and tropical Africa. Another species very closely resembling it is *P. Thunbergii*, Hook.; an immense tree known at the Cape as "Yellow Wood." Of the other species, most are large trees, and very few are hardy; but young plants of many of them are to be seen in cultivation in the Great Conservatory at Kew.

There are no other genera of Conifers with which it can possibly be mistaken. The regular and crowded arrangement, in two even rows, of the leaves of *Cephalotaxus* and *Torreya* suffice to distinguish them from it at the first glance. Its resemblance to some Bamboos is far more striking, though of course merely superficial.

Attention had already been called in this work[2] to the presence of *Podocarpus* in the Ardtun Beds. Scattered leaves are not very rare in the black shales, but their preservation did not admit of any description or further determination being hazarded. It cannot be identified with any of the numerous detached leaves that have been figured from the various Tertiary Leaf-beds of Europe. It best agrees with *P. hæringiana*, Ett. (*P. eocænica*, Unger, *fide* Heer), from Häring, and *P. eocænica*, described by Ettingshausen from Bilin, and from the Saxon Brown-coal, by Engelhardt. Its complete absence from all the Arctic Floras described by Heer, and from all the Cretaceous and Tertiary Floras of North America, is far more important, and probably a fact of some significance in the history of the existing distribution of plants.[3]

[1] Newberry, Carruthers, Britten, and other botanists who have seen the specimens or the plate are agreed upon this.

[2] Pp. 13, 48.

[3] "Only three or four species are sufficiently hardy for cultivation in this country, and these require warm and sheltered spots. Other species are noteworthy for their great value as timber-producing trees in their native countries, as the Totara Pine of New Zealand, the *Podocarpus cupressina* of Java, &c."—'Veitch's Manual of the Coniferæ,' p. 317.

The certainty that it is quite distinct from the typical *Podocarpus eocænica*, in which all the above-named specimens have been included, though perhaps erroneously, and from any others hitherto described, necessitates a new specific name, and I have therefore pleasure in naming it after the Duke of Argyll, to whose researches we were first indebted for our knowledge of the flora.

Detached leaves are not uncommon in the third or lowest bed at Ardtun. The fine specimens on Plate XXVI are preserved in a close-grained matrix not unlike the celebrated lithographic stone of Solenhofen, and are now deposited in the British Museum.

GINKGO ADIANTOIDES, *Unger*. Plate XXV.

GINKGO BILOBA, *Procacc.* Annali di Bologna, An. 1°, vol. i, 209, pl. iv, fig. 3, 1838.
SALISBURIA ADIANTOIDES, *Unger.* Synopsis, p. 211, 1845; Chloris Protogæa, p. lxxvii, 1847; Gen. et Spec., p. 392, 1850.
— — *Massal. e Scarab.* Flora foss. del Senigalliese, p. 163, pl. i, fig. 1, pl. vi, fig. 18, pl. vii, fig. 2, pl. xxxix, fig. 12, 1859.
— PROCACCINII, *Massal. e Scarab.* Id., p. 165, pl. xxxix, fig. 1, 1859.
— BOREALIS, *Heer.* Flora foss. arctica, vol. i, p. 95, pl. ii, fig. 1, pl. xlvii, fig. 4*a*, 1868.
— ADIANTOIDES, *Heer.* Id., vol. i, p. 183, pl. 47, fig. 14, 1868.

Basaltic Formation; Ardtun Head, Isle of Mull.

Leaves from two to four inches in diameter, broadly fan-shaped or flabelliform, somewhat resembling those of the Maiden-hair Fern, wedge-shaped at the base, leathery, more or less cleft into two lobes, smooth, undulating, and sometimes notched at the margin. Foot-stalk stout, equalling or exceeding in length the radius of the leaf. The veins not only spring or diverge from the base, but also from two strong ribs into which the petiole splits, and which border the lower sides of the leaf; the veins extend thence to the upper margin without diminishing in size, and are minute, dichotomous, equi-distant, and sub-parallel, forking as often as necessary to maintain their relative distances. Between these are quite disconnected, short, elevated, dotted, and spindle-shaped regions, discernible in the fossil, and mistaken by Massalongo[1] for parasitic fungi. These are best seen in the recent leaf by holding it to the light, when they appear trans-

[1] 'Flor. foss. del. Senigalliese,' 1859, p. 87, pl. i, fig. 1, *Sclerotites salisburiæ*, Massal. Saporta has suggested in a letter, and Mr. Murray of the British Museum has confirmed the view, that these are resin-chambers. They are referred to by Dr. Bary ('Vergleichende Anatomie,' English translation, p. 442):— "In the lamina of Ginkgo, in place of the uninterrupted canals, there are, between the vascular bundles, short cylindrical sacs, 1 mm. or more in length, which are closed blindly at both ends."

parent like the veins. The veins are very well defined and slightly elevated on the under side of the leaf (figs. 1 and 3, Pl. XXV), but less easily traced on the more wrinkled upper surface, figs. 2, 4, 5. The latter figures exhibit the undulations or folds such as are frequently seen in the leaves of the living tree.

The specimens from the newly noticed bed at Ardtun are far larger and better preserved than any previously found in Tertiary Rocks. In a layer of white clay at the base of the bed they are of a purple colour and massed together in the greatest profusion. The specimen (fig. 3) is from this layer and shows the texture, after maceration, to have been such that the venation of an immediately underlying leaf is distinctly visible through the one above.[1] They are much larger than the average in the living species, if we may judge from dried specimens and those in cultivation, but a garden variety has been produced in France in which the leaves often measure five and even six inches across.[2]

The Ginkgos are very large trees indigenous to China, where they seem, however, as yet to be unknown in a wild state. When stripped of their leaves there is nothing to indicate, externally, that they belong to the Coniferæ. The peculiarities of their internal structure and a brief sketch of their ancestry are described on pp. 45 and 122 of this memoir.

There can be no reasonable doubt about the specific identity of the Ardtun fossil and the living *G. biloba*, Linn., yet as only the foliary organs of the former are known, we should hardly be justified in making it an exception to the rule which has hitherto conferred distinct specific names on plants of Eocene age, no matter how great their resemblance to existing species may be. We can hardly admit the identity of the magnificent Scotch species with the starved Cretaceous form from Greenland, to which the name *G. primordialis*, Heer, was applied: but we cannot regard the British form as distinct from *Ginkgo* or *Salisburia adiantoides*, Ung.,[3] though the largest of the specimens figured by either Heer or Massalongo under that name do not equal in size those shown on Pl. XXV. When, however, a trinomial system is adopted, as must some day happen, its full name might well be *G. biloba hebraidica*, with the addition of *foss.* or *f.* for fossil, thus rendering any confusion impossible.

I had never heard that *Ginkgo* occurred in Mull, until I found a few imperfect specimens this year in the black beds of Ardtun; but its presence had long been known to the Duke of Argyll, who had, indeed, for many years, possessed a specimen in his Museum at Inveraray. It is, as already stated, abundant in the light-coloured beds of Ardtun, and the fact that this singular tree flourished within the British area in Tertiary times should be of some interest to botanists as well as geologists.

[1] The leaves, though leathery when freshly gathered, become relatively thin when pressed, and underlying leaves can be seen through them, as in the case mentioned above.

[2] Gordon's *Pinetum*, *S. adiantifolia macrophylla*, Hort., p. 375, 1880.

[3] It abounds chiefly, it appears, at Hare Island, a few miles north of Disco, and at Atanekerdluk. Heer has also noticed fragments from the grey clays of Samland, on the Baltic.

TAXUS CAMPBELLI,[1] (TAXITES, *Forbes*). Plate X, fig. 1; Plate XXVII, figs. 1—3.

Basaltic Formation; Ardtun Head, Isle of Mull.

The species was described at page 41 of this memoir from the unique specimen in the Museum of Practical Geology in Jermyn Street, as *Sequoia Langsdorfii*, Brong.; the figure (Pl. X, fig. 1) seemed to justify, or at least not to contradict, the universally accepted view promulgated by Heer as to its generic affinity with *Sequoia*. My personal researches in the Ardtun leaf-beds in the present year have, however, shown me that this accepted view is erroneous, and have upheld the correctness of Brongniart's and Edward Forbes's original determination. In justice to these most able observers, I embrace the opportunity of withdrawing a correction, which I am now convinced was unjustifiable. Unger, Weber, Goeppert, and others had repeatedly described twigs with similar foliage under the name *Taxites*, believing them to belong to the Yew or the Yew tribe; and nothing is more remarkable than the way in which authors permitted every yew-like twig of Tertiary age to be swept into the genus *Sequoia*, when we examine the evidence upon which the change in the nomenclature was based.[2]

There are many peculiarities in the Ardtun Conifer which are not met with in the Redwood, but are characteristic of the Yew, though they are perfectly indistinguishable, in either the fossil or recent state, by the actual form of the leaflets. Foremost among these is the fact that the foliage of the Redwood, shed in summer and autumn, breaks up and falls in the vast majority of cases as simple, unbranched twigs, many of which are very long, and comprise two or three years' growth. The Yew behaves quite differently, the majority of the twigs shed remaining compound. The specimens figured, as well as others, suffice to show that the fossil species by no means broke up in the manner of the Redwood, but distinctly after that of the Yew. Another character which can be detected in very few fossils, the stem being generally a more or less indistinct coaly mass, is the insertion of the leaves. In *Taxus* the base is constricted, almost petiolate, where it approaches the stem, swelling out again into a sort of cushion where it is adnate or embraces the stem;[3] while in *Sequoia* the constriction is more apparent than real, being chiefly due to the sharpness of the twist made by the leaf in becoming decurrent to the stem, and there is never any sort of thickening. In consequence of this the leaves are comparatively readily detached in the Yew, and most persistent in the Redwood.

[1] See *Sequoia Langsdorfii*, p. 41, for history and description.

[2] For many years all the yew-like foliage of the Tertiaries was determined as *Sequoia Langsdorfii*, and its presence, as in Mull, went far in giving the age of the beds as Miocene.

[3] The leaves clothing the branchlets, which are destined to remain attached for a long time on the Yew, become more and more constricted with age at the point of contact with the stem, until at last they become distinctly articulated and fall off, leaving the stem clothed with the scale-like bases of the leaves only. This never happens in *Sequoia*, where the whole leaf remains attached as a spiny scale until it decays away.

Though I had not noticed the peculiarity when I drew the enlargement (fig. 1, *a* on Pl. XXVII), I am sure that the fossil agrees with the Yew, and that the leaves have not the twist of *Sequoia*. Again, there is the absence of *Sequoia* cones in the beds at Ardtun; while, on the other hand, there is a small coaly disc in contact with the apex of the specimen, fig. 1, which might be a male flower or bud of *Taxus*, and an indistinct disc among the leaves of fig. 2, which might be a berry; I wish, however, to lay no stress on these. Finally, we have in the specimens a greater general resemblance to *Taxus cuspidata* and *T. adpressa* than we have to *Sequoia sempervirens*, specimens of the first-mentioned Yew, in the Kew and British-Museum Herbaria, even reproducing the little imbricated spike at the apex of fig. 2.

In addition to positive evidence, there is the negative fact that all the plants yet determined from the British Basalts are now indigenous, if still living, to Western Asia and Eastern North-America—among them being *Onoclea*, *Ginkgo*, *Cryptomeria*, *Podocarpus*, the *Cypress*, and *Pines*. *Taxus* would be at home in such company, while it is almost needless to say, *Sequoia* would not. Against this evidence there is nothing opposing to set. *Sequoia Langsdorfii* no doubt occurs in many places in Europe, but Heer's claims for it—perhaps in some cases put forward without an examination of the specimens themselves—were too comprehensive, and the species is in great need of revision.

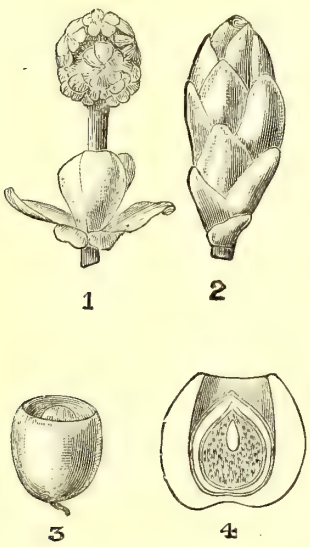

Fig. 38.—Fructification of the common Yew. (1) Male or staminiferous flower; (2) Female or ovule-bearing flower; (3) Ripe fruit; (4) Longitudinal section of the seed showing the position of the embryo. ('Veitch's Manual,' p. 296.)

It seems no longer necessary to retain the generic name "*Taxites*" in this case; for either the fossil is *Taxus*, or else some quite different Conifer. It cannot be identified with certainty with any of the many other European Eocene forms described as *Taxites Langsdorfii*, and there is no alternative but the pleasing one of restoring the specific name originally given to it by Edward Forbes.

Taxus adpressa, Knight, of Japan, is a dense, spreading, and depressed bush, seldom growing more than six or eight feet high. *Taxus cuspidata*, Siebold, which the fossil chiefly resembles, is described by Gordon as a large, handsome bush, densely clothed with somewhat ascending branches, and dark green foliage, growing from fifteen to twenty feet high, found in the Island of Jesso and to the South. Veitch describes it as generally solitary in the forests of this island, attaining a height of from thirty to forty feet, with a trunk from one and a half to two feet in diameter. The branches are spreading, and the general aspect is less dense than the common Yew, and with a somewhat more irregular outline. The leaves are broader, more abruptly pointed, more leathery in texture, and lighter in colour than those of the European species.[1]

[1] 'Manual of the Coniferæ,' p. 306, James Veitch and Sons, 1881

NOTES ON THE ADDITIONAL SPECIES OF CONIFERÆ.

As already remarked, the Eocene plant-beds were by no means exhausted when the description of the Coniferæ was undertaken. On the contrary, greater interest has been aroused, and, in addition to the grant made by the Royal Society, a Committee of the British Association has been formed to continue their exploration. The results of this assistance so far as the Coniferæ go are to be found on Plates XV to XXVII, and include many of the most satisfactory and finest specimens. Fresh discoveries have rendered it highly probable that all the Coniferous twigs and leaflets found at Reading and Croydon, though so varied in appearance, may really have belonged to a single dimorphic form of *Taxodium*, indistinguishable from *Glyptostrobus heterophyllus* of China and Japan. They could hardly have been placed in one species without such undeniable evidence as that furnished by specimens from Reading, which show the distinct kinds of foliage on the same branch. The abundant specimens of that singular extinct ally of *Agathis*, *Doliostrobus*, have been furnished by Mr. E. A'Court Smith, and a visit to Gurnet Bay has enabled me to reproduce the large specimen (Plate XXIII), by means of which, we are enabled to form a satisfactory idea of its habit of growth. But far the most important additions to our Coniferæ, are the fine species of *Podocarpus* and *Ginkgo* procured from the Isle of Mull, and which Prof. Newberry and others acknowledge to be the most beautiful fossil remains of these plants ever obtained. They are from a bed from which no collections had previously been made, composed of hard and very fine-grained cement-stone of a pale French-grey and buff colour, which was not described in detail when the Duke of Argyll referred to it as the lowest of three Leaf-beds, in 1851. The Irish Tertiary Basalts and plant-beds have been described in the preceding pages,[1] and it will be of interest to supplement them by an account of those of Scotland.[2]

The Scotch Eocene Basalts.—The position and contour of the beds at Ardtun Head, in Mull, were very fully described by the Duke of Argyll when the occurrence of fossil leaves among the Basalts was first made known. The Head faces Staffa and the Treshnish Isles, which are mere fragments of a once continuous sheet of solid rock that has been cut up and, as it were, dissolved away like so much sugar. As monuments of the resistless power of the waves no scene can be more impressive than this range of scattered islets stretching towards the Atlantic. Most of them appear as horizontal as the slate of a billiard table, and such sheets, extending for miles in every direction, show the overwhelming volume in which the Eocene Basalts must have been discharged. Directly opposite Ardtun, on the other shore of Loch Scridain, is the gigantic headland of Bourg, rising to a height of 1600 feet. This

[1] See p. 77.

[2] They will constantly be referred to in describing the Flora.

mass is composed of some four and twenty horizontal sheets of lava of great thickness, and furnishes the key to the position of the Ardtun and Staffa beds in the series, for Cretaceous and Jurassic rocks crop up at its base. The eruptive series commence with two great deposits of ash, each twenty or thirty feet thick, followed by some 100 feet of lava, the upper bed of which seems part of the flow forming the beautiful columnar beds of Ardtun and Staffa. An interval of rest followed, during which the fluviatile beds of Ardtun were deposited; these being represented at Bourg by nine to twelve feet of clays and sand without fossils. They are overlain by a bed of rudely columnar Basalt, identical with that which overlies the leaf-beds and forms the capping at Ardtun. Next is a bed of scoriaceous lava, thirty feet thick, which has caught up a few flints, and a bed seventy feet thick of remarkably compact lava. Above this again is about 1000 feet of lavas, some very much decomposed, with little if any intervening ash-beds, only a few thin beds of which reappear towards the summit.

It can hardly be doubted, in view of their great horizontal extent and vertical thickness, that nearly the whole of these lavas were formerly continuous, for no less majestic cliffs of the same composition form parts of coast lines east and west, and north and south. Time, however, has not spared them, and scarcely anything now remains at Ardtun and the Isles of all the long series of flows, except portions of two of the lowest and oldest sheets. The under part of the inferior of these is transformed into such columns as those which have made Staffa famous, though they are no less beautiful at Ardtun; while the upper one, imperfectly columnar and much fissured and jointed, forms still more precipitous and picturesque cliffs, presenting the appearance of ruined masonry. Sandwiched between these is a mass of sedimentary rock which reaches a maximum thickness of over thirty feet. A small chine or ravine marks almost the centre of the headland, and it was here that the Duke's published sections were taken. The eastern face is the more accessible and best to work, and it was at this spot that I decided to carry on somewhat extensive quarrying operations, whereby the following beds were penetrated. Resting upon the amorphous Basalt is a bed of carbonaceous rubble filling in the inequalities of the lava and about a foot thick, succeeded by two feet of indurated sand or grit. The true leaf-bed, the second in the Duke's section, follows; and though now a hard and brittle black shale, was originally a fine carbonaceous mud. It is two feet four inches in thickness, the lower part squeezed and without recognisable fossils; then a few layers containing numerous specimens of a simple ovate leaf;[1] another layer squeezed and with only macerated remains, and finally some layers made up almost wholly of large palmate leaves, known as *Platanites aceroides*. Overlying this, and distinctly separated, is a bed, a foot thick, of very hard whin-like rag, doubtless sandy carbonaceous mud when deposited, containing very large leaves of the so-called *Platanites*, with broken up fronds of *Onoclea* and *Equisetum*. The next bed is similar, marked off by a definite plane of bedding. It possesses few if any fossils, and passes gradually

[1] *Rhamnites*, Forbes, in the Duke of Argyll's Memoir.

upward into a mass of indurated gravel seven feet thick. In the ravine the gravel bed is externally as black as the lava, but fresh surfaces of the rock, shattered by blasting, showed a clear steely, French-grey matrix, with pure white flints so firmly cemented that the fractures had invariably passed through rather than round them. Here and there were stones of a cherry-red, and closer inspection revealed that many pebbles of almost the colour of the matrix had likewise been broken through. This pudding-stone, or indurated gravel, passes upward gradually into purer sand, eight feet thick, and comparatively soft and fissile at the top. The final parting between the sedimentary beds and the lava above is a rubble similar to that at the bottom.

This ravine proved, however, by no means the best spot, either for observation or collecting, though the most accessible. It appears in fact to be due to the weathering out of a dyke, now decomposed. The pressure of the upward passage of the incandescent mass has squeezed and distorted the plant beds and discoloured the gravel. The latter appears so altered as to have been mistaken for a volcanic agglomerate, but closer examination shows that it has the bedding of true river-gravels, and that all its materials are water-worn. Eighty yards farther east it has thickened to twenty feet, and the sand preserves its original colour. The current-bedding is beautifully shown, together with the drifts of shingly gravel and some small round boulders, so that no one could fail to recognise at the first glance its fluviatile origin. In addition to the leaf-beds at the ravine already described, which are continued unchanged, we find underneath, in descending order, a second gravel bed, of finer grain, three feet thick; two feet of grey clay with larger leaves in the rust-coloured partings; six inches hard laminated gritty sandstone with leaves; three inches hard lavender and buff cement-stone with very well-preserved leaves; one foot grey clay, with a thin layer at the base, literally choked with leaves in fine preservation, but very difficult to remove; six to nine inches clunch, inclined to be concretionary, with rootlets; and lastly, a thin layer of carbonaceous matter and grey clay filling in the inequalities of the old lava surface. There is a considerable variety of leaf in the lowest leaf-bed, but the most striking and abundant are those of *Ginkgo*. In addition to the dyke now weathered out, the Head has been traversed by an extensive sheet of Basalt, which has forced a devious way upward at a low angle through the series; and this also, owing to denudation, comes to the surface at the ravine. It is twenty to thirty feet thick, readily distinguished by its superior hardness and density, and finer grain; and it obliterates the sedimentary beds for some distance where it crosses them. The gravel, however, soon reappears; and where last seen, at a distance of 700 yards from the ravine, is still twenty feet thick. The fluviatile series is therefore of considerable extent, and its importance has been much underestimated. It is now known to occur at Carsaig on the other side of the Ross of Mull, at Bourg, and in Loch Na Kael, and it will be interesting to trace its limits in other parts. Though the gravels are unfossiliferous at Bourg, a large tree,[1] with a trunk five

[1] The wood is carbonised, and charred. Mr. Healy has kindly examined it microscopically and pronounces it Coniferous; and Mr. Carruthers thinks it might possibly be a trunk of *Podocarpus*.

feet in diameter, has been enveloped as it stood, in one of the underlying lava-beds. Owing evidently to its solidity and substantial girth, it resisted erect the fiery embrace of a torrent of molten and liquid lava forty feet in depth, for the outer layers are still preserved; but subsequent prolonged exposure to damp and wet, acting from above, slowly rotted the heart-wood, until little of the trunk remained beyond a cylinder or well choked with rubble. A little further on lies the limb of a great tree, which, long before the Ardtun river flowed in this direction, had helped with other débris to fill in a fissure.

The examination I have made of the area surrounding the Ardtun leaf-beds, has convinced me that these latter are stratigraphically much nearer the base of the Basalts than the corresponding plant-beds of Antrim. Having regard to the greater thickness of the series in this part of Scotland, and especially to the presence of extensive ash-beds at its base, it is difficult to come to any conclusion other than that the Ardtun beds are the oldest; and the opinion I had formed as to the relatively greater antiquity of the Irish plants must thus be accepted with reserve. As far as its bearing on geology goes, my work on fossil plants is for the present, and probably must be for some time to come, destructive rather than constructive.[1] Stratigraphical and physical evidence helps us but little in these vast volcanic regions, and nothing but the most patient investigations will ever bring the débris of plants, so wonderfully preserved in them, into line with other organic fossils and make them acceptable to the geologist as trustworthy indications of age. Our greatest hope of success lies in continually checking them off by the fossil floras of the South of England, where the entire series of beds which make up the great group or formation called the Eocene is displayed in a compass that not only renders their study easy, but makes it certain that they are not separated from each other by very great intervals of time. The age of each of the plant-beds included in this series is as absolutely known as any fact of geology can be, for it is checked in every case by the intercalation of deposits, teeming with marine and estuarine Mollusca, which are acknowledged by everyone to be conclusive proofs of age. The discovery in the lowest of these beds of types of plants which, until now, have been believed universally to occur only in the Miocene would alone have rendered a complete revision of the whole subject necessary.

The explorations and quarrying operations in the Ardtun beds were carried out by means of a grant from the Royal Society.

[1] I am able to state that certain plants are not peculiar to the stages they are believed to characterise, and hence that the ages of many plant deposits have been determined on erroneous premises. I have reason to believe that other plants are absolutely confined in some areas to beds of very different age to what has been hitherto assumed, and that many plants from different areas, believed to be identical, are really not so. But I cannot yet claim that fossil Floras offer evidence of age of the same value as fossil Faunas.

RETROSPECT.

HISTORY OF THE GYMNOSPERMS.

The imminent publication of more than one work on the evolution of plants led me to defer the detailed sketch of the history of the Gymnospermæ, which would have found an appropriate place in the Introduction to the present volume. Viewed from an evolutionary standpoint the Gymnospermous plants assume an importance out of all proportion to the position they occupy in classifications based on living plants, or to their numbers and variety at the present day. They comprise and reveal to us many of the stages traversed between the Cryptogam and the Angiospermous Phanerogam, and alone bridge over the vast interval between these most widely separated divisions of the vegetable kingdom.

In endeavouring to trace the stages through which the progressive evolution of plants has been accomplished, we must beware of assuming that every less complex organisation is necessarily of greater antiquity than all those which are more highly developed. Combinations of circumstances exceptionally favorable to certain groups of plants have sometimes forced on their development to a state never afterwards surpassed, but which, on the contrary, may have retrograded by the dropping out of prematurely developed types. New series, however, have perpetually branched off to replace those eliminated, and the great vegetable kingdom has thus, as a whole, uninterruptedly progressed.

Before quitting the Coniferæ it is necessary, in order to make clear the relative position in a progressive series which they occupied, to say a few words on the lower forms of vegetative life. The study of the British Tertiary Flora has so far thrown little additional light on the evolution of the Coniferæ, and the present brief sketch of their past history is therefore mainly compiled from the works of other and more distinguished authors, to whom I take this opportunity of expressing my deep obligations.[1]

[1] I am greatly indebted to Prof. W. C. Williamson, who has kindly revised the sheets relating to Palæozoic plants, and for the use of his numerous and most valuable papers on Carboniferous plants in the 'Philosophical Transactions of the Royal Society;' to Mr. Carruthers for his many valuable suggestions and the information contained in his numerous works on fossil plants; to Saporta's magnificent work in the 'Paléontologie Française,' 2me série, "Végétaux fossiles," on the Plants of the Jurassic Formation: and Saporta and Marion's "Evolution du Règne Végétale," Phanérogames, vol. i, 'Bibliothèque Scientifique Internationale,' 1885. The full details of the theory of plant evolution, which I have attempted to sketch, though with considerable modification, are given in this work. The information derived from these authors is the basis of so much that I have written in these pages, regarding the older plants, that a general acknowledgment of my indebtedness to them must suffice.

I have also extracted much information from Bentham and Hooker's 'Genera Plantarum;' Sach's 'Text-Book of Botany;' various papers by Sir William Dawson; Schimper's 'Paléontologie Végétale,' &c.

It is well known that the lowest of all forms of life may be equally relegated to either the animal or vegetable kingdoms. These, the Protista are either amorphous or composed of cells filled with protoplasm, a complex living substance endowed with internal forces conferring upon them variability, in other words, vitality. It is not improbable that the earliest primordial plants may have possessed no higher organisation than this. There are dredged, say Saporta and Marion, on the southern shores of France, creatures several centimetres in length, whose substance is entirely penetrated with fine particles of the sea-bottom. They would pass unnoticed did they not shift their position with extreme slowness and vary their form by the extrusion and retraction of short prolongations. Placed in a glass of sea-water they attach themselves to the sides, and free themselves gradually of sand, when a slightly yellow hyaline jelly, absolutely deprived of nucleated elements, is disclosed. They are allied to the *Protamœba* and *Pelobius*, and from these starting-points all the progressive stages of development are traceable.

In certain of the Protista cellulose envelopes are developed, and when further certain portions of the protoplasm become separated and assume a green colour, and are thereby converted into chlorophyll, all the characters of vegetable life are realised. The presence of this special substance gives rise to a whole series of new physiological functions; though present in some animals, it essentially characterises vegetable life. A principal distinction between the two kingdoms is thus due at the outset to the transformation of part of the elementary protoplasm into granules of chlorophyll.

In progressing upward the structure of plants becomes increasingly complex, and a nucleus appears in the cells. By gradual stages the Protophytes or Thallophytes are reached, including the single-celled Desmids and Diatoms, with hard or soft envelopes, the Confervæ, Fucoids, the higher Algæ, Florideæ, and Characeæ. The Fungi are destitute of chlorophyll, and hence, or owing to their parasitic and saprophytic habits, any further development in them seems to have been arrested.

While the more highly organised and complex Algæ have retained the aquatic habits necessary to their existence, some forms of *Nostochineæ*, *Palmelleæ*, and *Vaucheria*, seem from time to time to have quitted the water to occupy humid places on land. These furnish the earliest indication of adaptability to aërial life; and it is curious to find this proceeding from the lower types, but slightly differentiated from each other morphologically, rather than from the higher types of Algæ. Saporta and Marion assume that when dry ground appeared some of the lower Algæ with flat cellular fronds, such as *Ulva*, gradually took possession of damp or marshy spots and, creeping face to the ground, became ancestors of the Hepaticæ ;[1] while others, more confervoid and possessing a thallus with apical growth, have increased in complexity while adapting themselves to subaërial

[1] This is merely conjecture. Prof. Williamson, who has kindly looked through the proofs, reminds me that the Hepaticæ possess a thallus with apical growth (see Sachs, p. 347), and he has plants of *Metzgeria furcata* showing it.

conditions. Foliar appendages were probably given off, and a sort of plantlet with strictly cellular root-like and leaf-like organs would thus have come into existence, capable, like the Mosses of the present day, of agamous reproduction. Such a primordial cellular plant constitutes the first stage of growth, not only of Mosses and Hepaticæ, but also of Ferns, Equisetaceæ, Lycopods, and Ophioglosseæ. They are developed from the spore and closely resemble the lower Algæ in their purely cellular structure.

Saporta and Marion also regard the relatively early or late appearance of sexual organs in the life of a plant as exerting a predominant influence on its susceptibility to become differentiated or modified through the force of the changing circumstances which surround it. Those among the primitive terrestrial Algæ in which sexuality was deferred until late had a longer period of purely vegetable life ; and were thus not only more susceptible to the influence of new conditions, but had a longer time in which to adapt themselves to them, and so become diversified in type. Among the results of this elaboration they place the existing Mosses and Hepaticæ. In the Mosses the spore gives birth to a conferva-like thallus, called the Protonema, a reversion in all probability to a primitive ancestral stage. The growth of this elementary thallus, or purely cellular plant, is never arrested by the development of sexual organs, and is thus peculiarly susceptible to differentiation ; foliar buds are given off in places from its ramifications,[1] the increase of cells at these points assumes a regular plan, and little by little small laminæ take the form of leaflets borne on a stem supported by radicles. These radicles are capable of producing new plants and propagate so energetically that extensive carpets of moss may be formed without the aid of reproductive organs, which, indeed, are rarely present in some species. When present, however, they are of great morphological importance, and are distinguished as male, or "antheridia," and female, or "archegonia." The male is generally a club-shaped body, attached to the stem, filled with small and crowded cells, each of which contains an antherozoïd. The female organs, when mature, are in shape of a flask with a long neck, bulging from a narrow base and composed of a number of cells, of which the central, basal one is the largest and develops the oospore. At maturity the antherozoïds escape by the rupture of the antheridium and enter the archegonium. A new plant is produced by the oospore, which develops within the archegonium in which it is born and finally becomes the stalked organ called capsule or fruit in the Mosses. This so-called fruit bears no resemblance morphologically to the fruit of a Phanerogam, but is in reality a distinct asexual generation or separate plantlet, called by Sachs a "sporogonium," which gives birth to the spores ; which spores, falling in damp places, give rise to a new sexual generation of thallic, or moss plants. This alternate generation is unknown among Algæ, and the Hepaticæ and Mosses therefore introduce a new point of departure, the more developed and conspicuous of the two generations being very analogous to Algæ, while the less conspicuous sporogone is agamous, subordinate, and incapable of disengagement from the archegone in which it is formed ; yet it is fundamentally an independent plant. The

[1] Most frequently from the root-hairs, according to Williamson.

Hepaticæ are similar in growth, and, with the Mosses, present a stationary group which has elaborated a special kind of differentiation, but, since evolution has acted exclusively on the first generation, in a direction limited by biologic conditions.

Some of the vascular Cryptogams, as the Ferns, Equisetaceæ, and Ophioglosseæ, present a further stage of development. Their life-history, as in the Mosses, is divided into two generations which are extremely different, not only morphologically but physiologically. Their spores give rise to a cellular thallus or "prothallium," never differentiated as in the higher Mosses into a stem and leaf, but producing sexual organs, namely, archegonia and antheridia. The sporogone, or young plant of the second generation resulting from the fertilisation of the archegonium, instead of remaining a mere fruit-like appendage of the sexual plant, as in the Mosses, is vigorous and independent, and speedily supplants the ephemeral parent prothallium. As soon as free it takes root and finds its own nourishment; its tissues become extremely diversified, and fibres and vessels, histological elements previously unknown, are developed, and plants known as Ferns and Horse-tails result. In some of these the spore-producing generation, or sporogones, attain great age and very considerable dimensions, as in Tree-ferns; but on the leaves of all alike spores are born whose germination produces a new generation of humble cellular prothallia. The vast preponderance of this new vegetative system, the sporogone, is already manifest, and in the next grade of plants we shall see that the independent sexual generation is still more effaced.

In the Rhizocarpeæ, Selaginelleæ, and Isoëteæ, a yet further step towards the evolution of the highest plants, the Angiosperms, is made, for the separation of the two sexes is foreshadowed in the two kinds of spores which they produce.

Of these the *macrospores* are female, for they develop a prothallium bearing exclusively female organs; and the *microspores* male, inasmuch as their smaller prothallia only bear male antheridia. In the Rhizocarps distinct progress is made towards the suppression of the sexual generation, for the female prothallium is so reduced that the sporogone appears to be almost directly disengaged from the macrospore. Merely a small appendage remains formed and nourished in the macrospore, and with only a very small external development. In the sporogone of the Rhizocarp a "sporocarp," or kind of fruit, appears, which is formed through the differentiation of some of the fronds, and contains both micro- and macrospores enclosed in sporangia; in Marsilia this fruit reaches the highest point of complexity to be met with in existing Cryptogams. The Selaginellas and Isoëtes present an equal development, for the prothallium is retained within the macrospore itself as a mass of cell-tissue, in which true archegonia appear, destined to receive the antherozoïds on becoming exposed by the rupture of the cell-wall of the spore. In the microspores the male prothallium is a wholly rudimentary organ reduced to a single vegetative cell without function, and apparently a useless appendicle to the antherozoid-producing cells which accompany it. To complete the metamorphosis to Phanerogams the only further step required is that the macrospores should be fertilised

in situ on the plants; and already in the plants last described they have a tendency to become less readily detached than the microspores. This stage may have existed among the extinct allies of the Selaginellas, and we shall meet with it in the Gymnosperms.

The alternation of generation which is so eminently characteristic of the Cryptogams takes place within the seed of Phanerogams. The second generation, which is absent altogether in Algæ, and so inconspicuous in the Mosses that it never develops beyond the fruit-like cup in which the spores are produced, preponderates in the Ferns, whilst in the Gymnosperms the first generation is so completely hidden that it never emerges from the seed. We have thus seen that, if we omit the Fungi, the progress of evolution, from the simplest cellular plant to the most complex vascular plant, required that reproduction by sexual functions should be accomplished during a certain stage by means of a separate and special generation. The first trace of such a dual generation is to be found in the capsule of the Mosses, where the second generation is rudimentary, and has no separate existence. A host of intervening forms must have disappeared between this and the next group, the Ferns, for in these not only is the second generation thoroughly distinct, but the first has sunk into a short-lived and humble cellular plant, while the second has developed into a magnificent vascular plant which sometimes attains tree-like proportions. The first generation, now subordinate, is soon destined to disappear altogether, and in the Rhizocarps, as already mentioned, a vast stride is made towards this consummation. Two separate kinds of spores are produced, in the larger of which the once independent first generation appears as an inclosed cellular mass within which the female organs are developed, so that practically the larger spore has become a seed. With the next step in the progress of evolution, the slender line dividing Cryptogams from Phanerogams is crossed. The Cycads are the nearest on the other side of this dividing line, and in them germination takes place in the macrospore or seed, while it is still attached to the plant, instead of after it has been shed.[1]

Before passing on, however, to the true Gymnosperms, we have to notice a consider-

[1] Before dealing with these it is well to become familiar with the terms used by botanists in speaking of the organs of Phanerogams, which are different from those used for the functionally corresponding organs in Cryptogams.

Cryptogams.		*Gymnosperms.*
Archegonium.	Equivalent to	Corpuscle.
Antheridia.	„	Anther.
Thallus and Prothallium.	„	Endosperm (part of the seed).
Sporogone.	„	Plant.
Microspore.	„	Pollen-grain.
Macrospore.	„	Embryo-sac, oosphere, the germinating cell (part of the seed).
Microsporangium.	„	Pollen-sac.
Macrosporangium.	„	Ovule.
Spore-bearing leaves.	„	Stamens and carpels.

able group of extinct Carboniferous plants which united the characters of the Lycopodiaceæ and other Cryptogams with true exogenous stems. Though not in the direct lines of evolution, for the truly Gymnospermous *Dadoxylon* equals them in antiquity, they probably reveal the lines through which the passage from Cryptogams to Gymnosperms has taken place. Believed by Brongniart, Grand'Eury, Renault, Saporta, and Marion to have been Gymnospermous trees, they have been the subjects of prolonged discussion and research. The laborious investigations of Prof. Williamson had gradually made it clear that their peculiar exogenous growth was shared by the undoubtedly cryptogamous Lepidodendron, and the confirmation by M. Zeiller of Goldenberg's discovery that Sigillaria had spore-bearing strobili, has now confirmed Williamson's contention that they must be classified with Cryptogams.

As the earliest connecting links between Cryptogams and Phanerogams their morphology is peculiarly interesting, and the exquisite preservation of many of their silicified or calcified stems permits the minutest details of their structure to be studied.

That Cryptogams reached a far higher stage of development in the Palæozoic time than exists in any surviving representatives has not been disputed. One of the best known of these is *Lepidodendron*, the vigorous and splendid growth of which formed one of the culminating developments of the *Lycopodiaceæ*. The complex organisation possessed by them, even to the minutest points of internal structure, is very remarkable. "They formed large trees with acicular or falcate, perhaps, at a late period, deciduous leaves, and bore cones at the extremities of the branches, which differed exteriorly but little from those of some Gymnosperms. The expanded bases of the scales or bracts bore the sporangia, those containing the macrospores being nearest the base of the cone. In all the species the stem consisted of several layers. In most the centre consisted of a parenchymatous pith. In some this pith was only represented in its young state by one or two isolated cells, but these rapidly multiplied, developing into a conspicuous medulla. In one or two others these medullary cells were replaced by a solid rod of scalariform or barred Tracheids. In a third type barred Tracheids were developed within the cellular medulla—but at the periphery of the latter they rapidly coalesced into a vascular cylinder. In another type this cylinder was developed *pari passu* with the medulla, the boundary-line between the two being sharply defined. In all cases the vascular bundles proceeding to the leaves were composed of barred Tracheids derived from this primary vascular cylinder, the vessels of which were never arranged in radial lines. Even in its youngest state the bark investing this primitive, non-exogenous, vascular zone exhibited three layers—an inner, often delicate parenchymatous one, a median prosenchyma, which ultimately attained to great thickness, and a permanently thin superficial parenchyma.

"In most *Lepidodendra* there was developed, sooner or later, a second and more external vascular zone, the vessels of which were arranged in radiating laminæ and which was unmistakeably an exogenous development from a Cambium layer.

"*Lepidodendron*, like the greater part, if not all, of the Palæozoic Flora, became extinct

during the Permian period, leaving *Selaginella* and *Isoëtes* as its humble surviving representatives.

"*Sigillaria* closely resembles *Lepidodendron* in its organization. As in the latter, its exogenous vascular zone is richly supplied with medullary rays through some enlarged and symmetrically arranged forms of which the foliar vascular bundles, wholly derived from the inner non-exogenous vascular cylinder, pass obliquely upwards and outwards, on their way to the leaves."[1]

Professor Williamson describes the prosenchymatous and the parenchymatous structure investing the woody zone as a bark, and remarks that, although not divisible into layers identical with those of the Phanerogams, the enormous development of the elongated prosenchymatous fibres, or bast-tissue, in the interior of the fossil stems is a manifest foreshadowing of the presence of that same tissue in the bark of living exogens, especially the Cycads. There is no difference of opinion as to the exogenous nature of the second or outer vascular cylinder, though it bears a relatively small proportion to the diameter of the stem, nor as to the presence of representatives of medulla or pith, and bark; but while the French School, including Adolphe Brongniart, B. Renault, Saporta, Marion, and Grand'Eury, class *Sigillaria*, in consequence of its exogenous wood, as a low form of Exogen, Mr. Carruthers, Sir J. D. Hooker, Prof. Williamson, and many of the German authors have always regarded it as a highly-developed Cryptogam. It appears from Williamson's long-continued researches that the exogenous wood is not always developed in the young stages, either of *Sigillaria* or *Lepidodendron*, and that there is a gradual passage from one to the other. Sir W. Dawson, a great authority on the subject, now believes that some *Lepidodendra* are exogenous, and Prof. Williamson considers that eventually all may be found so.

The roots of these plants are known as *Stigmaria*, and are looked upon by the French School as rhizomes, capable of bearing leaves as well as roots, but as merely roots with rootlets by other observers. The erect and cylindric Sigillarian stems were crowned with a mass of long and linear leaves, whose scars have impressed their complex and beautiful tesselated designs on the trunks.

The next type of exogenous stem is still more remarkable, and its importance as one of the connecting links between the Cryptogams and the Gymnosperms cannot be overestimated. *Calamodendron*, of Brongniart, but which Carruthers and Williamson affirm is merely another name for *Calamites*, possessed a hollow stem with verticillate leaves, somewhat resembling a gigantic Equisetum. This was filled in solid with pith or cellular parenchyma when extremely young; but soon becoming hollow with age, the fistular interior consisted at last of a vertical series of oblong chambers, separated from each other by transverse diaphragms, and lined with a very thin film of cells. The exogenous zone, the presence of which has led to *Calamodendron* being classified by French authors with

[1] This description of the structure of the stems of *Lepidodendron* and *Sigillaria* has been kindly furnished by Prof. Williamson, to whom I am deeply indebted for it.

the "Progymnosperms," consisted of numerous woody wedges separated from each other, in the younger states, by peculiar vertical prolongations of the pith, to which Prof. Williamson assigns the name of primary medullary rays, while his secondary medullary rays separate the constituent vascular laminæ of each wedge as in recent Exogens. The wedges extended vertically from node to node, and their apices or inner faces originated in a vertical duct or canal. Investing this woody zone, and very rarely preserved, was a cellular layer without vessels, the structure of which is, as yet, but imperfectly known. In the young state it consisted of a thin layer of parenchyma composed of cells of various sizes. At a more advanced stage of growth these developed a thick internal prosenchymatous layer like that of *Lepidodendron* and *Sigillaria*. The outer surface appears to have been smooth, not fluted longitudinally, and the articulations to have been inconspicuous. The exogenous wood thus surrounded the pith, and somewhat resembled, in its arrangement, the first year's shoot of a recent Conifer. The rootlets (formerly called *Primularia*) grew from near the nodes and were branching. The arrangement of the appendicular organs on the young trunks was verticillate, and the leaves or branchlets were distributed at regular distances on the line of nodes, which were pretty close together, but the branches became few and irregular in older stems. Though there is no direct proof that such is the case, Saporta and Marion hazard the opinion that the foliage known as *Archæocalamites* and *Bornia*, which consists of repeatedly dichotomosing or acicular leaves, arranged in verticels around nodes, on slightly striated stems, belongs to *Calamodendron*, together with a male inflorescence born in catkins something like those of *Taxeæ*. Sir William Dawson states that he has found, on the other hand, the leaves attached to the stem in five species of *Calamites*, and in such relations as to give satisfactory proof as to their nature; and has shown that they are similar in form and external markings to the so-called branchlets of modern *Equiseta*. The fact is there is much difficulty in determining the true relations which the verticillate leaves of *Asterophyllites*, *Sphenophyllum*, and *Annularia* bear to their several stems.[1] Prof. Williamson has described a homosporous strobilus which he thinks belonged to *Calamites*; whilst he has found both homosporous and heterosporous ones which belonged to other allied Asterophyllitean plants. Saporta and Marion call attention to the resemblance between the leaves of *Bornia* and those of *Trichopitys* and *Bryon*, which are true *Salisburieæ*;[2] for, though the former are verticillate and the latter spiral in arrangement, the possibility of an easy transition from one to the other is shadowed forth in some Lycopods, and both dispositions occur together in existing *Cupressineæ* and the young *Abietineæ*.

Another remarkable Carboniferous stem with exogenous wood is described by Prof.

[1] Prof. Williamson remarks that "the structure and true relations of the roots and leaves are, as yet, the least known part of the history of Calamites." Very different looking organs occurring *in sitú* at Saint-Etienne are figured as roots of *Calamites* and *Calamodendron* respectively, 'Mem. de l'Acad. des Sciences,' 2nd series, vol. xxiv.

[2] [*Salisburieæ*—a family proposed to receive the numerous extinct as well as the solitary living species of Ginkgo.]

Williamson as *Astromyelon*. It appears that the stem and branches grew together in exactly the same relation as those of an ordinary exogenous tree, the branching not differing materially in its outward appearance from that of a Pine. He considers it a Cryptogam whose affinities were possibly with *Marsilea;* and that the large radiating lacunæ of the bark show that it was at least semi-aquatic in its habits.

Contemporaneous with these were many varieties of truly gymnospermous stems. M. Renault finds that the wood of *Poroxylon* is dotted with areolated puncta similar to those distinguishing the spiral vessels of Cycads and Araucarias; and Sir W. Dawson has described no less than five species of the Coniferous *Dadoxylon* from the American Middle Devonian. Prof. Williamson long ago demonstrated that the supposed British plants known as *Sternbergiæ* were merely inorganic casts of the hollow discoid pith of a *Dadoxylon*, and he has more recently shown that in some of these *Dadoxylons*, double foliar bundles pass off to each leaf-petiole, as in the recent *Ginkgo* or *Salisburia*. That the Gymnospermæ had already attained a considerable numerical development in the Carboniferous Period is still more apparent from the seeds met with in certain localities. The affinities of *Trigonocarpus* with the drupaceous seeds of the existing *Ginkgo* were pointed out by Sir J. D. Hooker and Mr. Binney as long ago as the year 1855.[1] Mr. Carruthers, in 1872, figured two species of *Cardiocarpon* attached to their axes,[2] and clearly pointed out their Gymnospermous character. The fortunate discovery by M. Grand'Eury of a number of silicified seeds at St.-Etienne and Autun; and the magnificent posthumous work upon them of M. Ad. Brongniart, completed by M. Renault, has shed a flood of light upon the subject. These seeds have been placed in a number of genera, and are of many and diverse forms, but as yet it has not been possible to allocate them definitely among the previously known Carboniferous genera. Prof. Williamson, in describing a large series of similar seeds from the Carboniferous deposits of Lancashire and Burntisland, seems to have experienced the same difficulty.[3] Some of them are more complex than those of many existing Gymnospermous seeds, those provided with a testa and a double membrane recalling seeds of Cycads and Taxeæ, especially Ginkgo. Notwithstanding their divergence of form, from simply bicarinated to a structure composed of many radiating elements disposed round a common axis, they have one peculiarity in common, the possession of a cavity at their micropylar extremity, called the "*chambre pollinique*" by Brongniart, and the "lagenostome" by Prof. Williamson. Pollen grains, sometimes much larger than those of existing Gymnosperms, entered this chamber through the micropyle, increasing in size during their stay in it and developing septa or cell-walls internally. Underneath this, the lagenostome or chamber, is the albumen or endosperm. Germination has not taken place in any of the fossil seeds and the development of the embryo is unknown. The great importance of these seeds lies in the fact that

[1] 'Phil. Trans.,' vol. cxlv, part 1, p. 149. [2] 'Geol. Mag.,' vol. ix, pp. 55—57, figs. 1—3.

[3] "Eighth Memoir on the Organisation of Fossil Plants of the Coal-Measures," 'Phil. Trans.,' vol. clxvii, 1877, p. 213. M. Lesquereux has figured a number of similar seeds from the American Carboniferous.

their structure reveals, more clearly than do any existing seeds, the passage from the cryptogamic stage whence these early "Progymnosperms" had, so to speak, then but barely emerged.

Even the pollen grains themselves are not without interest when viewed from an evolutionary standpoint. Unicellular in Angiosperms, bi- or tri-cellular in Gymnosperms, they are seen to be distinctly pluri-cellular in "Progymnosperms," for the subdivision into many cells is said by Saporta and Marion to be discernible in all the silicified pollen grains of Carboniferous age yet studied.[1] The included male prothallium is supposed to be represented by the cells, and in that case has become merely rudimentary. Their relative size, reaching to half a millimètre, is remarkable, for this exceeds eight and a half times those of the Larch, the largest among living Coniferæ and twelve times those of Cycads and *Ginkgo*. But whatever the size, they are seen to have been divided into eight, twelve, or eighteen cells, the dividing septa of which are still perfectly visible. A considerable increase in bulk accrued to them, as we have seen, during their sojourn in the pollen chamber of the seed they had entered; while the female organ progressed simultaneously with the development of its *Corpuscula*, upon whose completion impregnation depended. That these cells are really the homologues of a rudimentary male prothallium has frequently been suggested, and it is due in a great measure to this structure and the position and development of the pollen-sacs, that Gymnosperms are admitted to occupy an intermediate position between vascular Cryptogams and Angiosperms. To this progressive and gradual obliteration of the independent sexual existence, characteristic of vascular Cryptogams, the evolution of Phanerogams is mainly to be traced.

Next, however, in relative development to the Dadoxyloid groups stands the "Progymnospermous" group or genus *Dolerophyllum*. This group deviates more or less considerably from the types we have hitherto considered, and in it we may hope to find the more immediate ancestors of true Gymnosperms.

The *Dolerophylla* were arborescent plants of large size, provided with leathery or thick, broadly ovate or orbicular leaves, with simple outer margins, but notched or auriculated inferiorly, sessile, and leaving a transverse scar of attachment on the stem which they closely embraced. These leaves were of considerable size and shed either singly or adhering to branches. They have been found principally at St.-Etienne, and also in the Permian of Russia. The leaves and branches were produced in great conical buds with convolute vernation. The veinlets are crowded, radiating, and dichotomous.[2] The lower epidermis was dense and provided with stomata, while embedded in the parenchyma and covering the veinlets are several rows of large elongated cells which contained gum or resinous sap. The organs of fructification are still incompletely known, but the

[1] Prof. Williamson thinks that the supposed cells may be but modifications of the sculptured extine.

[2] The veinlets are said to possess a duplex structure characteristic of the "Progymnosperms" and now only retained by the *Cycadaceæ*.

pollen-sacs were, according to M. Renault, disposed radially in double ranks upon, and partly embedded in, the surface of a not greatly modified peltate leaf. The pollen grains were very large, formed of many nearly equal cells, and doubly dehiscent longitudinally. The female organ, discovered by M. Grand'Eury, is an orbicular, scarcely metamorphosed leaf, hollowed in the centre to receive a single oval seed. In this primitive type the pollen-sacs are evidently homologues of the microsporangia of vascular Cryptogams; the pollen grains are the microspores, while the seed corresponds to a macrospore, germinating in position, and supported on a carpellary leaf.

Next to *Dolerophyllum* must be ranged the still more imperfectly known *Cannophyllites* of Brongniart, a plant with large leaves cut up into numerous segments, with median veins and numerous oblique veinlets, recalling leaves of *Scitamineæ*. In *C. Virleti*, Brongt., the leaves must have measured several feet in length and the stems have been also of great strength. Their nearest affinities are believed to be with *Psygmophyllum*, a prototype of *Ginkgo*.

Still more developed, and far more perfectly studied, are the Cordaïtes. This important group first appears in the Carboniferous and did not outlast the Permian, its extinction seeming at once to make way for a great development of the true Gymnosperms. They were large trees, varied, distributed into many genera, and possessing characters common to the Cycadaceæ, Taxeæ, and Gnetaceæ, yet being as a whole inferior to true Gymnosperms; a group developed rapidly, and which has left no direct descendants. The stem was large and repeatedly branched, and in some cases bore leaves several feet in length. The leaves were coriaceous and possessed a multitude of equal subparallel veins. Three different types are known and are placed in separate genera, the commonest form being relatively broad and blunt at the end. The leaf-scars are transverse and discoidal, or bent and elliptic, and disposed in quincuncial order on the stem. The simple, or rarely composite fruit-spikes, furnished with spikelets in two rows, occur among the leaves without definite order. The stem was composed of a central pith; a woody region possibly identical in some cases with plants described under the name *Dadoxylon;* and a thick cortical region, divided into an inner parenchymatose, and an outer denser zone, traversed by fibrous cells and resinous canals. The reproductive zone was at the inner periphery of the cortical region or bark, and corresponded with Cycadean and certain monocotyledonous stems, rather than to those of acicular-leaved Coniferæ. The leaves had the progymnospermous structure which is still retained in the Cycadaceæ. The male and female organs were inserted in the axils of bracts on a floral spike. In the male the axis is short and furnished with bracteoles, and carries a number of staminal leaves either in a terminal cluster, or else spirally disposed. The staminal leaves bear three or four erect and terminal pollen-sacs, corresponding morphologically to microsporangia. The pollen grains contained in them are large and elliptic, composed of a finely reticulated integument that splits longitudinally, and an endospore composed of as many as ten cells. In the female, carpellary leaves corresponding to

Macrosporangia take the place of the staminal ones, each containing a macrospore clothed in a double membrane, similar in construction to seeds already described, and more complex than those of any existing Conifer. The *Cordaïtes* were the most developed of the extinct "Progymnosperms," and nearly equalled true Gymnosperms in the relative perfection of their organism. Though highly specialised, this betrays a decided approach to *Ginkgo*, not only in the form of the leaves, which are broad, blunt, and sometimes bilobed, but also in their organs of reproduction, more especially the seeds named *Cardiocarpus*, which almost exactly reproduce those of *Ginkgo*.

The "Progymnosperms" are not entirely extinct, for one order, the Cycadaceæ, has survived with little variation to the present day, and the living species preserve, almost unmodified, the characteristics of their remote ancestors of Carboniferous age. Their general growth and external appearance were briefly described in our Introduction,[1] but the probable course of the evolution of the Gymnosperms cannot be sketched without more particular reference to the details of their internal structure.

The Cycadaceæ are allied to true or acicular-leaved Coniferæ mainly through their reproductive organs, whilst in many other respects they are far less developed. Their relative inferiority is especially apparent when the internal structure of their stems is contrasted, for these correspond in plan with such primitive types as *Poroxylon* and *Cordaïtes*, and differ remarkably from the truly exogenous stems of the higher Gymnosperms. A fully matured stem of *Cycas* is composed firstly of central pith; secondly, a single cylinder or zone of primary wood without exterior rings of growth; thirdly, one or more regions of liberian parenchyma and an equal number of woody cylinders; fourthly, the cortical parenchyma; and fifthly, the hypoderma or zone of increase.[2] The permanent bases of the petioles contribute to the latter and make an external covering of considerable thickness. Both the woody zones are traversed by medullary rays, but the second is engendered later than the first, and has a different origin. The fibrous elements of the woody zones are marked with rows of obliquely elliptic areolations, differing, according to Saporta and Marion, alike from those of true or cone-bearing Coniferæ and from other "Progymnosperms," but recalling somewhat more the structure of *Ginkgo* and the Taxeæ. The general plan has little in common with that of the Coniferæ or Dicotyledons; but, due allowance being made for the branching habit and presumably more rapid growth, bears a striking analogy with that of *Cordaïtes*.

The leaves of Cycadaceæ are, according to Sachs, of two kinds; the one described as "dry, brown, hairy, sessile, leathery scales, of comparatively small size," the other large and pinnate, that is, provided with distinct segments inserted on the sides of a usually simple support. In the forms both of the scale-leaves, and of the modified leaves which support the sexual organs, Saporta and Marion see reasons to infer that the now pinnate foliage-leaves must have been originally simple or merely fimbriated along the margins,

[1] *Ante*, p. 14.

[2] See Carruthers' "Memoir on Cycadean Stems," 'Trans. Linn. Soc.,' vol. xxvi, p. 675.

then incised and segmented, and lastly pinnate; in which cases they would have once presented a remarkable affinity with certain abnormal *Cordaïtes* and *Salisburieæ*. The analogy is increased by the presence, common to all these, of a peculiar cellular tissue, called "*tissu lacunaire*," in the middle of the substance of the leaf and uniting the veins.

The flowers of the Cycadaceæ are always diœcious, the plants being either male or female. They are placed at the summit of the stem, and in all the genera except *Cycas*, they externally resemble fir-cones. The female flower of *Cycas* is composed of a whorl of metamorphosed foliage-leaves, several of the lower pinnæ of which support ovules. These attain a considerable size even before fertilisation, and the fertilised seed "acquires the dimensions and the appearance of a moderate-sized ripe apple, hanging quite naked on the carpel."[1] The stem continues to grow through the whorl of modified leaves forming the female flower, developing first a whorl of scale-leaves and then new whorls of foliage-leaves. Saporta and Marion point out that this is the utmost simplification of which phanerogamous plants are capable, and indicates very clearly the stages through which their evolution from Cryptogams must have progressed. The male flower is composed of numerous smaller undivided staminal leaves, expanded from a narrow base and crowded on the under side with pollen-sacs. In other Cycads the staminal or carpellary leaves are disposed on a shorter and relatively slender stem, and become often hard or lignified. The pollen-cells or microsporangia are grouped in clusters of three or five on the under side of the staminal leaves, like the sori on Ferns. They open longitudinally, and, according to Sachs, "are in all respects much more like the sporangia of Ferns than the pollen-sacs of other Phanerogams, from which they also differ in the firmness and hardness of their wall."[2] The relative size of the grains, their often elliptical form and median furrows are, on the other hand, special to Cycads. The grains are at first formed of only one cell, but subsequently this divides into two cells, the larger of which becomes fashioned into the pollen-tube whilst the smaller again subdivides, so that a Cycadean pollen grain is normally three-celled; a character helping to assimilate the *Cycads* with ordinary Gymnosperms. The carpellary leaves are crowded in a spiral arrangement on the axis of the female flower, except as just described in *Cycas*, each one bearing two ovules on the under surface of the peltate or expanded lamina. Saporta and Marion regard it as probable that they were originally more numerous, covering the surface of the limb, and that the reduction in number is an advance in their evolution. In *Cordaïtes* the fruiting organ is a shoot with greatly modified leaves, the main axis bearing only sterile bracts, from the axils of which the staminal or carpellary leaves are developed, while the bracts serve as involucres. In *Ginkgo* the male flower consists of an axis with staminal leaves bearing pollen-sacs at their summits, much as in *Cordaïtes*; but in the female flower there is no axis, and it consists only of isolated carpellary leaves springing from the axils of foliage leaves, and bearing two, or rarely three, ovules at its extremity.

[1] Sachs, p. 503, English Edition, 1882.

[2] L. c., p. 504.

Supposed Cycadaceæ occur in the Upper Carboniferous,[1] and in the Permian several genera are distinguishable. In the Rhætic series representatives of *Cycas* were already differentiated from the rest, or Zamieæ, but even when most numerous and diversified the limits within which they varied were very circumscribed. Their oldest known ancestor is *Noeggerathia foliosa*, of the Middle Carboniferous; and although the leaves even in this are pinnate, those destined to bear the organs of reproduction are little metamorphosed and but slightly smaller than the foliage-leaves. The ovules also were smaller and far more numerous than at present, and for these reasons *Noeggerathia* is justly regarded by Saporta and Marion as a primitive type of Cycad in process of evolution. *Pterophyllum* and *Nilssonia* succeeded it, and already in the Secondary Period the numerous genera did not (with the exception of *Bennettites*) differ in any essential points of structure, so far as is known, from the species living in the present day. They become increasingly rare

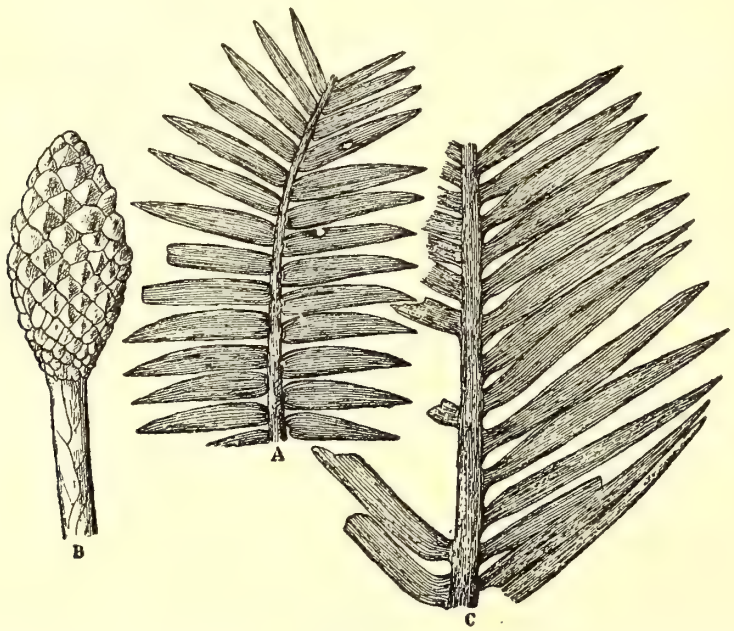

FIG. 39.—The last "European" Cycads. A. *Zamites epibius*, Sap., from the Oligocene of Bonnieux (Vaucluse); a frond of small size. B. *Zamiostrobus Saportanus*, Schimp., female cone from the Oligocene of Armissan (Aude). C. *Encephalartos Gorceixianus*, Sap., middle part of a frond from the Miocene of Kumi (Eubœa), two thirds natural size.—After Saporta and Marion.

as Cretaceous times are passed, and appear to have completely died out in Europe with the Tertiary Period, evidently declining under the competition of newer forms and only surviving in specially favorable stations.

In arriving at the "true Gymnospermic" stage of Saporta and Marion we definitely leave behind all those genera of ambiguous and prototypic character which we have hitherto had under consideration. In these we have traced step by step how the purely

[1] *Pterophyllum Grand'Euryanum*, Sap. and Mar., a plant discovered by M. Grand'Eury, is regarded by Saporta and Marion as a primitive Cycad. 'Evolution des Phanérogames,' vol. i, p. 109, fig. 58.

sexual generation has gradually been suppressed as an independent existence. The spore and the prothallium have become one, and the sexual stage reduced to a few cells, representing the prothallium, developed in the embryo-sac in the seed and in contact with the rudiments of a female prothallium. The pollen grains of Gymnosperms, are according to Sachs, homologous with the microspores of *Selaginella*, since they are subdivided internally into cells representing a very rudimentary male prothallium. The largest of the cells ruptures and becomes transformed into the pollen-tube. The pollen-sacs containing the grains of pollen are produced on the inner sides of staminal leaves, either in pairs or in larger groups, and open at maturity to set free their contents. The macrosporangia are each reduced to a single macrospore called a nucellus or ovule, and may be formed either of the metamorphosed end of the floral axis; or be axillary; or proceed from the carpels. The carpels never cohere so as to form a true ovary before fertilisation, hence the term Gymnosperm; although on ripening they often increase in size so considerably that they close together and conceal the seeds. Cases are, however, "not rare in which the seeds remain quite naked from first to last."[1] One or more embryo-sacs are formed near the apex of the ovule or seed. An endosperm or mass of cellular tissue corresponding to the prothallium of Cryptogams is formed in the embryo-sac, and within this arise Archegonia or Corpuscula. The pollen-tubes penetrate the ovule and reach the corpuscle, impregnating the germinal cell within, called the oosphere, in which the embryo of the future plant subsequently appears. "During the development of the embryo the endosperm (prothallium) becomes filled with nutrient materials and increases greatly in size; the embryo-sac which encloses it grows at the same time, and finally entirely absorbs the surrounding tissue of the nucellus (ovule); the integument, or an inner layer of it, becomes developed into a hard shell, while frequently (in naked seeds) its outer mass of tissues becomes fleshy and pulpy and gives the seed the appearance of a drupaceous fruit (*e.g. Cycas, Salisburia*). The effect of fertilisation extends to the fertile leaves, which enlarge, swell, harden, and approach each other, and constitute a complex organ, the fruit forming fleshy or woody coatings to the seeds (*e.g.* Juniper), or woody supports beneath them as in Coniferæ."[2] The reproductive organs of the Gymnosperms are thus seen to be very complex. They are simplified in the still higher Angiosperms by the final obliteration of the Archegonia or Corpuscula and of the endosperm or prothallium contained in the embryo-sac, whilst the pollen grains or microspores become almost unicellular, and thereby lose the last trace of the inclosed male prothallium of the Lycopodiaceæ. The seed develops gradually as it ripens, its function being to protect the embryo and to store up nutriment for its use when germinating. The embryo lies in the endosperm which fills the seed and is differentiated distinctly into stem, root, and leaves.

The "true Gymnospermæ," comprehending the order CONIFERÆ only, have a branching stem, usually arranged in verticels round a central axis. Interiorly the stems are truly

[1] Sachs, p. 498.

[2] Sachs, p. 499.

exogenous, composed of a woody interior and of a bark, these being most distinctly separated from each other by the reproductive cambium layer, which produces annually a new layer of wood on the one side, and of bark on the other. As in the Cycads, the true vessels are confined to the periphery of the greatly reduced central pith. The fibrous wood is arranged in concentric zones without any mixture of intercalated bark, and is uniformly composed of punctated fibres, radially disposed and traversed by medullary rays. The wood is destitute of true vessels and only contains an insignificant proportion of woody parenchyma, except in a few Conifers of relatively rapid growth. The great advance is the permanence of the cambium layer and the consequent regular increase of

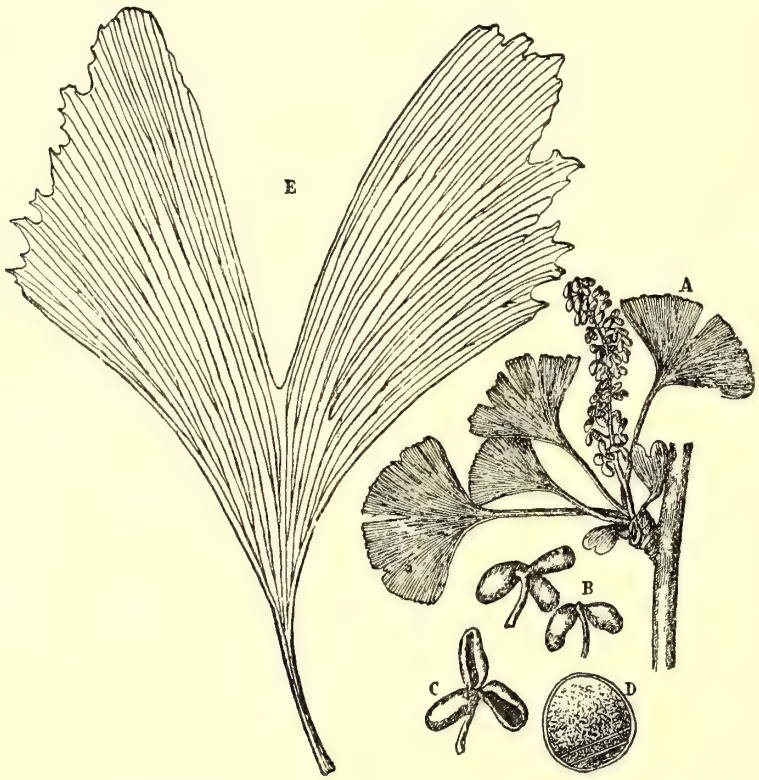

FIG. 40.—Leaves and male organs of *Ginkgo*. A. Lateral branch and male catkin, on the point of emitting the pollen, surrounded by young undeveloped leaves. At the base are two bilobed bracts. B and C. Detached flowers. D. Pollen grain greatly magnified, showing a three-celled interior, surrounded by extine. E. Leaf, two thirds natural size, of the wedge-shaped and deeply-cleft variety. —After Saporta and Marion.

the stem, a growth exclusively confined to the Coniferæ and to Dicotyledons, and the complete separation of the bark from the wood. The bark is composed of three elements, the fibrous inner bark or liber, the parenchymatous second layer, and the outer or suberous bark covered by the epidermis. The leaves are always simple, generally narrow, and most often seated on more or less decurrent cushions, provided with longitudinal veins, solitary or several parallel, simple or forked, but never anastomosing or even joined

by intercalated veinlets. The *Ginkgo* presents in many respects a simpler organisation than the rest of the Coniferæ, and its study is therefore likely to bring us nearer to the starting-point of the Order than that of any other genus.

Ginkgo is the largest-leaved of the Coniferæ. The leaf is fan-shaped on a long and slender petiole, and the fan is generally more or less cleft in the centre and sometimes still further subdivided. There are two fibro-vascular bundles in the petiole from which fine dichotomosing veins proceed. Filling in between the veins there is beneath the epidermis a "lacunary" tissue formed of elongated cells, arranged in transverse bands which anastomose together. The same construction prevails in *Cycads*, and a not dissimilar one

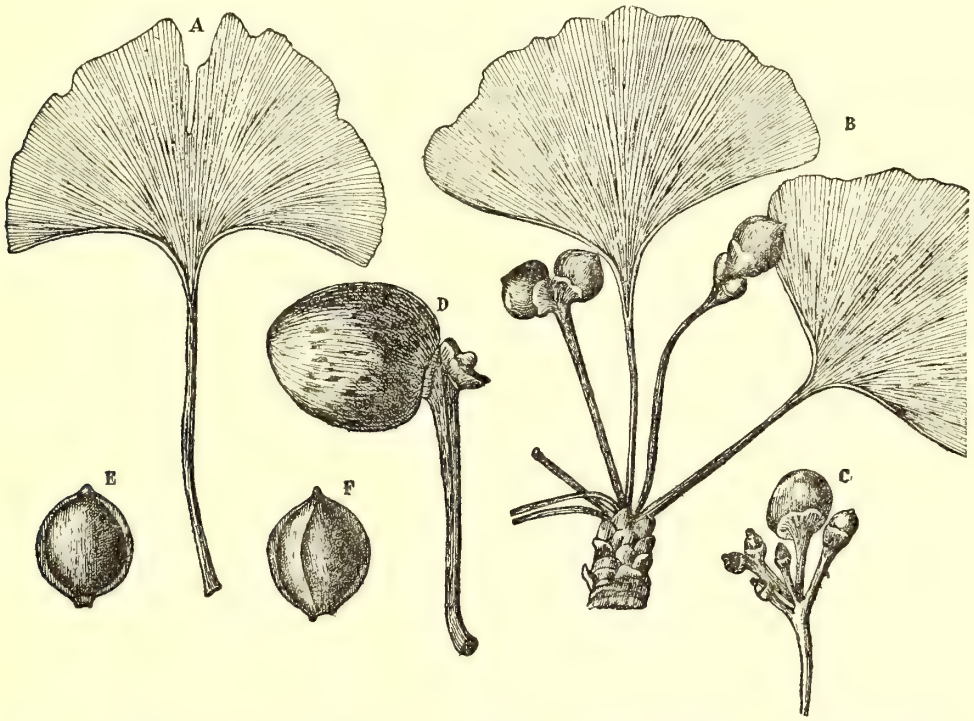

FIG. 41.—Leaves and female organs of *Ginkgo*. A. Bilobed leaf of ordinary type. B. Short lateral and flower-bearing branch, surmounted by a rosette of entire leaves and stems supporting recently fertilised ovules. C. Stem bearing a cluster of ovules on pedicels, only one of which is destined to be developed. D. Stalk bearing two ripe seeds, of which one has been removed to show the scar of attachment. E and F. A bicarinated and a trigonal seed with their fleshy envelopes removed. Half the natural size. After Saporta and Marion.

in *Cordaïtes*. The sexual organs are disposed on abbreviated lateral shoots. The male flower-spike is in form of a catkin, and axillary, each of the altered leaves of which it is composed bearing two or three terminal pollen-sacs at their ends, which depend from short peduncles, as in other *Taxeæ* and in *Cordaïtes*. The female apparatus is placed amidst a rosette of normal leaves, and consists of a group of petioles, supporting each two ovules instead of a bilobed leaf. The matured seed is more like, in structure, that of *Cycas* and of *Cordaïtes*, already described, than that of any other Conifer. Under a fleshy integument there is a hard testa in form of a bi- or tri-carinated nut, the large

kernel of which contains a bulky embryo, furnished with two unequal cotyledons. The stem has a relatively large pith, and by this, as well as by its punctated woody fibre and septiferous bark and some other characters, its relation to Cycads is apparent. The Ginkgos can be traced back to the Carboniferous through a series of increasingly modified forms, even those from the Permian being not dissimilar in aspect to those which still exist. Prof. Williamson is convinced that *Dadoxylon* was a closer ally of *Ginkgo* than of the Cycads, the leaf-bundles being in pairs, a peculiarity of construction now wholly confined to the former. The type was by no means isolated in the Carboniferous as at present, for many varieties of *Dadoxylon*, and fruits resembling those of *Ginkgo* are known, and its ancestral form *Ginkgophyllum* approaches both *Noeggerathia* and *Cordaïtes*, as well as the most ancient Cycadaceæ. The course of evolution does not demand that all Coniferæ should have descended from *Ginkgo* as a common ancestor, but the living species is certainly the only one which, apart from its exogenous trunk, can convey to us a faithful, if weakened, image of the Coniferæ as they existed in times anterior to the organic changes which transformed some into cone-bearers and others into Taxeæ.

It only remains now to trace as far as possible the evolution of the Coniferæ from the primitive type. The oldest examples known to us possessed an exogenous growth. Their leaves were broad and attenuated at the base with parallel dichotomising venation. The male and female inflorescence were separated, and formed spikes composed of bracts or metamorphosed leaves arranged round a central axis. The subsequent modifications have been in the direction of the successive reduction of the breadth of the leaf and number of veins, and their combination into a mid-rib; and it is amongst the most primordial genera, *Araucaria* and *Agathis*, that the largest leaves are to be found.

The Taxeæ are older as a group than the true Coniferæ. During the progressive development of the Coniferæ to their present state, great numbers of types must have been evolved which have since entirely disappeared. A few, more persistent than others, have come down to us and seem to reveal at least some of the stages by which the cone-bearing Coniferæ were differentiated from the rest. There has been a tendency in the Taxeæ for the floral axis to diminish, and in the other orders for it to increase. One well-nigh constant element in the Taxeæ and the Podocarpeæ is the swelling of the substance surrounding the base of the ovule until it forms either a membranous or fleshy cup. *Dacrydium*, *Podocarpus*, *Phyllocladus*, and *Taxus* are diverse examples of this. *Saxegothea* is perhaps the highest form of Taxad, for the bracts form a sort of cone, each scale of which bears an inverse ovule at its base, seated in a membranous cup. In the Yew the male flower is made up of a number of bracts, very like the inflorescence of *Equisetum*, as pointed out by Sachs; while the female flowers "spring from the axils of foliage-leaves belonging to elongated woody shoots and have the form of short branches covered with decussate scale-like bracts," the axis of the shoots ending in a terminal ovule.[1] The last is not dissimilar, according to Saporta and Marion, to that of the Abie-

[1] Sachs, p. 515.

tineæ, but the ovule in *Taxus* subsequently develops solitarily on its cup-like base, whilst the support in the Abietineæ takes a scale-like form. A primordial member of the Abietineæ, before the ovules were collected in a cone, should not differ fundamentally in its fruity organs from a primitive Taxad, before its floral axis had been impoverished. While, as already stated, it appears certain that the Taxeæ as a group preceded the true Coniferæ, it is probable that what are now alike cone-bearing Coniferæ were differentiated before the fruiting organs of some of them definitely took the form now common to all. The cone is a branch wholly or partially modified to serve as a support to the female organs, and to protect the seeds after fertilisation until they ripen. In the cones of Cycads the metamorphosed leaves directly support the ovules; but in Coniferæ these organs are situated on structures arising out of the axils of the bracts, which latter do not increase while the ovule-bearing structures are enlarging and producing the ovules. In the Abietineæ an entire branch is modified to form the cone, but in the Cupressineæ only the upper part is transformed. The occasional perfoliate cones of *Cryptomeria* and *Cunninghamia* demonstrate that the middle of the branch was the part originally modified, and that the sterile termination has since been lost through atrophy. In many of the older Coniferæ of the Trias and Rhætic the scales of the cones are more scattered and their leaves less completely altered, producing the long cylindrical forms which so often characterise primitive types such as *Voltzia*, *Schizolepis*, *Glyptolepis*, and *Lepidostrobus*. The most ancient Conifers of which we have definite knowledge, although there must have been still older types, are the *Walchiæ*, a considerable tribe of trees of large growth, clothed with deciduous foliage not differing greatly in appearance from that of *Araucaria Cookii* and *A. excelsa*. The cones, however, were small, ovate or oblong, with lanceolate scales formed of only slightly modified and closely imbricated bracteal leaves firmly attached to the axis. The seeds were small, slightly alate, and free, from one to three being born under each scale. In construction the cone is not unlike that of *Araucaria*, except that the latter possesses but one seed to each scale, and the bases are not persistent to the axis. The *Walchiæ* are associated in the Carboniferous with two genera of *Ginkgos*, *Ginkgophyllum* and *Trichopitys*, together with the last of the *Cordaïtes*. They are succeeded in the later Permian by *Ullmannia* which links them to the Jurassic *Brachyphyllum*. *Voltzia* of the later Permian and Trias is seen, by the disposition of its seeds, and in other respects, to be allied to the Taxodieæ, though its thin imbricated scales, forming a loose and rather large cone, link it also with the Araucarieæ. The Triassic *Albertia* bears a striking resemblance to *Agathis* in its cones, but in foliage it more resembles *Araucaria Bidwillii* and *A. Cunninghami*. *Glyptolepis*, a genus bearing cones with a long axis and small fimbriated scales, carries on the Voltzian type through the Upper Trias.

The commencement of the Jurassic period marks an epoch in the development of the Coniferæ, their characters for the first time approaching sufficiently to those now existing to enable the whole to be placed in living families. At the same time many of the archaic genera, such as *Walchia* and the Sequoia-like *Palissya*, do not survive beyond it, but make

way for the newer and more vigorous types which are ushered in with the first dawn of the Cretaceous period. Jurassic forests appear to have been composed mainly of genera belonging to the Araucarieæ and the Cupressineæ, with an undergrowth of Cycads and of various species of *Brachyphyllum* and Ferns.

Of the five tribes into which existing Coniferæ are grouped the Taxeæ, through *Ginkgo*, are decidedly the most venerable for their antiquity. The pedigree of this tree is so remarkable and is traceable through such ages, embracing as it does widely divergent forms separated into many genera, that Saporta strongly urges that the extinct ancestral and the living form should be elevated to the rank of a distinct tribe in classifying Coniferæ.

It is somewhat remarkable that while some of the Jurassic species of *Ginkgo* are almost indistinguishable from the living, they seem to have reverted during the Cretaceous and Wealden towards older forms, the leaves of at least one being laciniated or cut up into narrow segments. The Carboniferous *Ginkgophyllum* died out with the Permian, where it is associated with *Trichopitys*. The latter with *Baieria* persisted down to the close of the Secondary period. No other genus is known in the Lias, but in the Jurassic many species, some true Ginkgos, are met with ranging from Australia to within the Arctic Circle. The tribe had greatly diminished in the Cretaceous period though *Baieria* and *Sclerophyllina* were among the survivals. Its later history will be found at p. 46 of this memoir.

The rest of the Palæozoic Coniferæ cannot be placed with certainty in any one of the existing tribes. Their characters seem to unite the Araucarieæ, the Cupressineæ, and the Taxodieæ, and there can be no doubt that the remote period in which they flourished was antecedent to the differentiation of these tribes from each other. It has been proposed by Saporta to unite them in a single tribe, that of the Walchieæ of Schimper, and the advantages of this arrangement, at least as a provisional one, are obvious. The principal genera would be *Walchia*, *Ullmannia*, and *Brachyphyllum*. The latter was an immense genus, with very thick, closely inlaid, or imbricated leaves, and small cones, either persistent or caducous, composed of persistent scales which were also closely imbricated, and, not greatly differing, except that they were more lanceolate, from the foliar leaves. None of the Walchieæ so far as is yet known survived the Jurassic. *Brachyphyllum* is the last of the Coniferæ which cannot properly be classed in an existing tribe,[1] and in leaving it we seem to quit the unknown.

The Araucarieæ are of an antiquity which is only surpassed among Conifers by *Ginkgo*, though the Carboniferous woods, for a long time thought to be Araucarian, are now placed in the widely removed progymnospermous genus *Cordaïtes*. Undoubted Araucarian forms first appear in the Trias, but with ambiguous characters, which render it probable that they may be ancestors of all three existing genera. Mr. Carruthers was the first to demonstrate beyond all doubt that true *Araucariæ* existed in the Inferior Oolite of

[1] It is placed with the Taxodieæ by Schimper.

England; and their presence in contemporaneous beds has since been ascertained in France. The British species are *Araucarites sphærocarpus*, Carr., *A. Phillipsii*, Carr., and *A. Brodiei*, Carr., from the Inferior Oolite, and *A. Pippingfordensis* from the Wealden.[1] Two of the Jurassic species seem to have shed their scales similarly to the existing trees; but in the first the cone is unbroken and the scales are seen to have been woody and persistent like those of *Araucaria Bidwilli*, though otherwise resembling *A. excelsa*. The Greensands of France have yielded important foliage of undoubted *Araucariæ*, as well as cones, some of the latter as large as any now existing.

The Taxodieæ form another tribe of remarkable antiquity. The oldest form which can be placed with certainty in it is *Voltzia*, a genus which appears in the second half of the Permian. Two other genera, *Cheirolepis* and *Schizolepis*, occur in the Rhætic and Lias and are principally known from their small, elongated, and bracteated cones. The singular Rhætic *Palissya* is more completely known, the cones being frequently attached to the foliage, which is dimorphic, while the cone is composed of pointed and laterally lobed scales and pointed bracts. *Sphenolepis* is another fine Rhætic genus with terminal cones clustered together, which survived to the Cretaceous. The genus *Swedenborgia*, so far limited to the Rhætic of Sweden, and *Echinostrobus* of Solenhofen approach more nearly to the existing genera *Cryptomeria* and *Athrotaxis*. The Taxodieæ thus abounded in the Trias, and attained their maximum towards the close of that formation and in the Lower Lias, when they seem to have preponderated over all other plants showing a preference for humid stations. Thenceforward they declined and in the later Jurassics the Cupressineæ had already to some extent replaced them. *Sequoia*,[2] however, abounded in the Cretaceous period, especially within the Polar Circle, and a *Taxodium* also appeared before its close.

One of the most remarkable characteristics of this tribe, according to Saporta, is the tendency to polymorphism in the foliage of every genus belonging to it, not only with regard to different species of the same genus, but also in individual plants. This was especially apparent in the more ancient representatives of the family, and led the earlier authors to assign to different species foliage of *Voltzia* and *Palissya* which might have grown on the same tree, so extreme is the range in the size and form of the leaves. In describing the Eocene Taxodieæ during the progress of the present work, I have repeatedly called attention to the polymorphism which is apparent in many of them, a peculiarity still manifest in nearly every living species.

The entire tribe is certainly a declining one at present. The few genera comprised in it are represented by single or few species, and seem all decreasing and retreating relatively to the positions they formerly occupied, while none have maintained themselves in Europe.

The Cupressineæ seem to have been first definitely ushered in with the Jurassic

[1] 'Geol. Mag.,' vol. iii, p. 249; and vol. vi, p. 3.

[2] Probably the oldest species is described by Carruthers from the Gault of Folkestone, as *Sequoiites Gardneri*, 'Geol. Mag.,' vol. vi, p. 7.

period, and do not assume any important position until the Oolites are reached. A fragment of foliage with squamiform leaves, imbricated in four rows, appears to have been brought from the Carboniferous of Melville Island, but no other foliage bearing any resemblance to that of a Cupressineous plant has elsewhere been found in rocks inferior to the Upper Trias or Lias. In the older Jurassics the branches when met with are small and scattered, but in the Middle and Upper Oolites they are large, numerous, and of many types, though fruits are unfortunately always rare. Along with *Widdringtonites*, *Palæocyparis*, *Thuyites*, *Phyllostrobus*, none differing much externally from living forms, we come across the still existing genus *Widdringtonia*.

The Cupressineæ are believed by Saporta and Marion to be an offshoot from the same stock as the Taxodieæ, with the elements of the cone, diminished in number and more perfectly soldered and combined together, arranged on a decussate or verticillate plan. In the oldest known species of the existing genus, *Widdringtonia*, the leaves are imperfectly arranged in pairs, and the four scales of which the cones are composed are thought to be metamorphosed from them. The leaves of the Cupressineæ, at first irregularly disposed, as shown in Jurassic species, finally became in most of the genera regularly arranged in pairs, the lateral being compressed and keeled, and the front and back flattened. The highest degree of complexity is presented by the most recent type, the Junipers, in which the fleshy scales are soldered together so as to convert the cone into an edible berry. There is thus evidence of progressive development in the tribe which is now, next to the Abietineæ, the most extensive among Coniferæ.

The Abietineæ are regarded as an ancient tribe, with characters fixed in very remote times, which varied within small limits, and for a long time increased but very slowly in importance. They seem to have descended from an ancestry different from that of the two preceding tribes, whose common origin is apparent in many ways, and which were perhaps originally an offshoot from the stock which produced the Taxeæ. Saporta has long upheld the view that their cradle was in the extreme north of the hemisphere to which they are practically confined even now.

The researches of Dr. Nathorst have set the first appearance of the tribe as far back as the Rhætic of Scania. They reappear in the Inferior Oolite of Spitzbergen, where several genera seem to be present, and have been met with in Norway, Sweden, Siberia, and Spitzbergen, while they are all but unknown in the Jurassics to the south.[1] In Cretaceous times, however, they had spread farther south, and in the Neocomian, Gault, and Chalk of Belgium, the north of France, Normandy, and England, many curious species occur combining characters which are now distinctive of different genera and subgenera. Thus, the *Cembra*, *Tæda*, and *Pinaster* sections of *Pinus* were imperfectly separated; cones like those of Cedar were formed of persistent scales, but were themselves caducous, instead of possessing a persistent axis with scales which fall off as at present; and the

[1] A small cone with thin scales, from the Kimmeridge Clay, is described as *Pinites depressus* by Carruthers, 'Geol. Mag.,' vol. vi, p. 2.

characteristics of *Abies, Tsuga, Picea, Cedrus,* and *Larix* seem to blend and lose themselves in these ancestral species.[1] The types which were formerly the most widely spread now extend farthest to the south.

The structural characters of the cone are especially important in this tribe. The support of the ovule represents an axillary shoot reduced to a single phyllode, supporting two ovules, and is only slightly and superficially soldered to the bract. After fertilisation this support alone increases in size and forms the scale of the cone, while the bract dies away or presents no appearance different to an ordinary leaf. The ovules are always inverse and buried in the substance of the scale, usually becoming surrounded with a membranous wing formed from its outer cellular layer. The general appearance and later history of the tribe have already been described (p. 60) in this Memoir.

With the Cretaceous, or rather with that indefinite age which intervened between the close of the Cretaceous and the dawn of the Eocene, unrepresented by any stratified rocks in England, we close the book on the evolution of Gymnosperms, for nearly all the archaic anomalous genera which held the place of our Larches, Pines and Spruces, Cypresses, and Junipers, give way to living genera and even species.

[1] The following simple classification of the Abietineæ proposed by Saporta seems specially applicable to the needs of the geologist.

Tribes.	*Genera.*	*Sub-genera.*	
Pineæ.	Pinus	*Strobus.*	Leaves fasciculated by fives; apophyses terminal; scales of cone persistent.
		Cembra.	Leaves fasciculated by fives; apophyses terminal; scales of cone caducous.
		Pseudo-strobus.	Leaves fasciculated by fives; apophyses central; scales of cone persistent.
		Tæda.	Leaves fasciculated by threes; apophyses central; scales of cone usually caducous.
		Pinaster.	Leaves fasciculated in twos; apophyses central; scales of cone persistent or caducous.
Laricæ	Pseudo-larix		Leaves caducous; cone pendent; scales loosely imbricated, detaching themselves from the axis on maturity.
	Larix		Leaves caducous; cone erect, with scales persistent.
	Cedrus		Leaves perennial; cones with scales detaching themselves from the axis at maturity.
Sapineæ	Abies. Leaves inserted direct, and leaving a discoidal cicatrice	*Abies vera.*	Cones erect; scales detaching from the axis at maturity; bracts more or less visible, persistent at the base of the scales.
		Tsuga.	Cones small, terminal, pendent; scales few and persistent; leaves relatively broad and short, regularly distichous.
		Pseudo-tsuga.	Cones terminal, with persistent scales; leaves very linear and irregularly distichous.
	Picea		Leaves inserted on elevated cushions and decurrent.

The Break Between the Cretaceous and Eocene Rocks in the British Area.

It is a remarkable fact that the extermination of so much that was pre-existing of both the marine and terrestrial Fauna, embracing nearly all the shelled Cephalopods and all the gigantic Saurians which had till then occupied the foremost place, should have been accompanied by a similar wholesale disappearance among Plants. To suppose that this period was an exceptionally fatal one, annihilating entire orders of the animal kingdom, is to admit, in the complete absence of evidence, a break or jerk in the majestic progress of life upon the earth; and this is repugnant to common sense. It is more consonant with our present views to suppose that we are in presence of one of those vast gaps in the geological record which we know must have occurred over and over again in every upheaved area upon which sedimentary rocks had been deposited. In turning from the last Cretaceous deposit in Europe, we seem, so far as the Plant world is concerned, to finally break with the past, while the first deposit of the Eocene appears like turning over the first page of the history of things as we see them now. It is thus, perhaps, worth while to turn aside for a moment to take stock, as it were, of the closing events of the Cretaceous, so far as we know them at present, in order to estimate the true nature of the apparently sudden bound in the usually stately and measured march of evolution.

It appears that during the Chalk formation a great wave of depression passed across Europe, travelling from the west to the east, permitting the ingress of the Atlantic, and forming a gulf over what is now Central Europe, which constantly increased in magnitude. We need not believe that this gulf was formed by any sudden catastrophe, for there is no reason to doubt that the sea conquered the land by the same methods and at somewhere about the same rate that it encroaches now, and that therefore its advance over many thousands of square miles of *terra firma* would be an exceedingly lengthened process. We cannot gauge the time this occupied; but we know that since the appearance of Man Southampton Water has been formed, and a tract between Alum Bay and Studland, some fifteen miles long and five or six miles broad, has been swept into the sea, and several species, like the Mammoth, have become extinct. The rate of the encroachment depends mainly on that of the subsidence and the original height of the land, but what has here been effected in a subsiding area serves to show roughly how vast a time must have been needed for the chalk sea to have crept from Kent to the Crimea, and to have covered the enormous area of Europe over which its traces still remain. As the land subsided and became sea, blue and green muds were thrown down, to be succeeded in due course by the deeper deposits of chalky ooze. It would be physically impossible for the Chalk, supposing

it to represent Globigerina-ooze,[1] to have been directly deposited on a former land surface, and we consequently find that it is invariably preceded by some more littoral sediment. The nearer the original centre of depression or focus of subsidence, the older the Greensands and Gaults must necessarily be ; and the farther we recede from it in any landward direction, the newer they will be. Now, apart from physical evidence, a comparison of the Faunas of our Chalk with those of any European bed correlated with it to the eastward would at once show that if one were older than another, it would be that of our area. Forms like *Mosasaurus*, which only appear in our very latest Chalk deposits, abound in Cretaceous deposits of more central Europe ; whilst others, such as *Ichthyosaurus*, found abundantly in our Chalk-marl are, on the contrary, absent in them. The rapid increase in the proportion of long-canaled and other Eocene-looking Gastropods in the Chalk, as we recede from Kent and Sussex, reaches a maximum in the Danish Upper Chalk, and indicates most conclusively a more and more recent period of deposition for the beds in which they occur. The littoral and each subsequent zone must in fact have been constantly travelling outward and forward, accumulating only until

[1] True Chalk is a pure white limestone, composed of the remains of Foraminifera, valves of Ostracoda, excessively minute Coccoliths, shell prisms of Inocerami, Sponge spicules, and other débris of organic life. It was, until recently, admitted to be a truly oceanic deposit, of similar nature to Globigerina-ooze ; but Mr. Wallace, supported by the late Dr. Gwyn Jeffreys, has put forward the view that it was formed in shallow water ('Island Life.') Its vast extent, homogeneous nature, and freedom from terrestrial impurity, show that it must have been formed remote from land, while its larger organisms, mainly Echinoderms and Sponges, are, with some exceptions, such as are now met with in abyssal depths. Mr. Wallace laid some stress on the difference in composition of fresh Globigerina-ooze and Chalk, as shown by analysis ; but Mr. Murray has recently stated that the percentage of carbonate of lime varies from 40 to 95 in the ooze. The comparison took no account of the fact that the Chalk had been elevated for ages, during which it has acted as a sponge for the collection and percolation of rainwater charged with carbonic acid, which has been ceaselessly removing some of its original constituents. Its silica has been dissolved and re-precipitated as flint, its iron has been segregated into crystalline masses, its manganese into dendritic markings, siliceous sponge skeletons have been dissolved and replaced by calcite, calcite shells by silica, and aragonite shells removed entirely. Layers of Chalk a foot in thickness have been reduced to an inch by the removal of lime in solution. The late Dr. Gwyn Jeffreys had not studied the question, and based his conclusions upon the Mollusca only, and these chiefly of the Chalk-marl, and he seemed unaware that only the calcite shells remained in true Chalk. Of these shells *Terebratula*, *Pecten*, *Lima*, and *Spondylus* are the chief genera still existing, and all but the last are already known to inhabit water 1400 fathoms in depth. Moreover, if the Chalk sea did not communicate with the Arctic Ocean, as Prof. Prestwich and others believe, and was shut off from the Antarctic by land between Africa and South America, as there is also much evidence to support, its abyssal depths would have been warm instead of icy cold, and its former abyssal inhabitants, accustomed to warmth, would have sought shallower water in order to find an equal temperature, and become, as Gwyn Jeffreys states them to be, a tropical assemblage at the present day. The blue and green muds of the 'Challenger' pass into Globigerina-ooze with an increased depth, and their equivalents of Gault and Greensand pass into Chalk in exactly the same way. The alternative theory of Wallace, that Chalk is decomposed coral mud, could not have been advanced by a geologist, as while it contains some well-preserved solitary corals, not a trace of a reef-building coral has ever been met with either in or surrounding it, nor even in any contemporaneous deposit.

the ever-increasing depth led to a change in the sediment. Thus, though beds of Greensand or Chalk may be perfectly continuous, with precisely the same lithological characters, it is absurd to assert that portions of either when separated widely apart by degrees of latitude and longitude must be synchronous. So far from this, the Chalk-with-flints of one locality must most certainly have been deposited synchronously with the Chalk-without-flints of another, and this in turn with the Chloritic marl of another, and the Greensand of another. The shallower-water zones, such as the Greensand, would travel forward so long as the sea continued to encroach, and along the farthest confines of the gulf would recede again when elevation set in, without any Chalk having been deposited over them, so that some "Upper Greensands" might be newer than any Chalk. It is probable that each minor zone was a zone of depth, characterised by the same quality of sediment, and a Fauna to some extent peculiar to it, which kept up with it as it travelled farther and farther landwards. There might thus be great similarity (homotaxis) in the Fauna of each zone at long intervals of distance, and its distinct characteristics maintained over the most extensive areas, without, for all that, its contents having lived synchronously over the whole area.

We have noticed that the Neocomian and Gault of England and Western France contain a varied and considerable Flora, represented mainly by foliage and fruits of *Coniferæ*, without affording the slightest trace of the presence of angiospermous Dicotyledons. Even the Grey Chalk and the Blackdown Beds have only yielded Conifers and a *Williamsonia* of Jurassic type. We cannot account for their absence by supposing our area to have been isolated, for in the preceding Wealden period neither its Fauna nor Flora differed from that of Europe. But when we reach Aix-la-Chapelle, we find the Chalk and Greensand resting upon beds containing a Flora largely made up of Dicotyledons, and still farther off, in the Cenomanian[1] of Bohemia, living genera such as *Magnolia*, and farther on still, equally developed Dicotyledons in the slightly newer Turonian. Such facts were hitherto completely inexplicable, but it now appears probable that the interval required for the Chalk to progress even only 300 or 400 miles, may have endured long enough to permit an enormous progress in the evolution of phanerogams. Nor does the 1200 or 1400 feet of vertical Chalk remaining in our area, at all represent the completed formation; for, as the prolonged subsidence finally ceased and gave place to an equally slow elevation, all the lessening zones of depth must have travelled back with the receding ocean, and left a series of beds arranged inversely to that preserved to us. The planing action of the sea has removed all this newer series, just as it has planed away an older mass of the width of the English Channel; and it is still slowly but inexorably cutting down to its own level all the cliffs that form its shore-lines. The Eocene seas, from beginning to end, were ceaselessly engaged in this work, and their enormous deposits of flint shingle mark how much had fallen a prey to them. Nor have the Cretaceous rocks enjoyed any respite from the work of

[1] Equivalent of Grey Chalk and Chalk-marl.

destruction down to the present day, so that what remains is a mere fragment of what once existed.

It was during the interval that elapsed between the formation of the newest Chalk now left in England and the oldest Eocene, that Dicotyledons were introduced, if not actually evolutionised, and our existing Flora practically came into existence. All the Upper-Cretaceous Floras of Europe also flourished during this interval, but we cannot say, with our imperfect record, exactly the order in which they came in, and must be content to regard them, in a general way, as far newer than they appear to be stratigraphically. Much of the American Cretaceous series should, perhaps, also be placed somewhere in this interval, though many well qualified to judge regard it as dating from an older period. Without this digression we could not have formed so adequate an idea of the completeness of the break between the Eocene and the Cretaceous period, nor realised that the so-called Cenomanian and Turonian Floras of Europe may belong to epochs completely different from those represented by the same horizons in Kent and Sussex.

The break in the continuity of the history of the Coniferæ here introduced corresponds to that which actually occurs in nature in our area. It is not to be understood that this is the only gap in their history, for there are many, but there are none of such present importance (or that perhaps are less adequately realised), for it immediately precedes that chapter in their development with which we are most immediately concerned, and it is absolutely necessary, therefore, that its magnitude and duration should be recognised, in order to appreciate the meaning of the great change in the character of the Flora, which we find to have taken place in the interval.

We have already seen that several very anomalous genera of Coniferæ occur in company with Dicotyledons wherever Floras of late Cretaceous age are met with. The Aix-la-Chapelle Flora was very rich in these, and contains many new to science, which may now be open to study. The curious genera *Inolepis, Cyparissideum,* and *Spheno-lepidium* were mentioned at page 17 of this Memoir. *Cunninghamites,* a genus differing considerably from *Cunninghamia,* characterises the Cretaceous of Saxony and Bohemia. *Geinitzia* is another genus which has been found abundantly at Quedlinberg, also in the environs of Dresden, and near Neustadt in Austria. Its cones are cylindrical and elongated, formed of scales at right angles to the axis, with peltate or hexagonal heads marked with deep and converging grooves, and sheltering three or four wingless seeds at their base, while the foliage is dimorphic, being closely imbricated as well as looser like that of *Cryptomeria.* Nor must we forget that many of the supposed Cretaceous *Sequoiæ* are very imperfectly known, and may prove when examined, to be as anomalous as those of Aix-la-Chapelle already mentioned. It thus appears that a large proportion of even the latest of the Cretaceous Coniferæ belonged to types which have since become extinct.

It is quite otherwise when we reach the Eocene. The British Eocene Coniferæ bear,

with just sufficient exceptions to prove the rule, a remarkable resemblance to still existing species. In some cases the fossil and the living plants are, so far as their organisation can be compared, unquestionably the same species, though, even in these cases, they do not bear the specific names attaching to the corresponding recent plants. However well preserved, some of the organs necessary for accurate botanical determination are certain not to be in the perfect state requisite for proper examination, and we have therefore to rely greatly on superficial resemblances. It seems to be the opinion of botanists that they should not, under such circumstances, be definitely united together. For all practical purposes, however, their identity might, in some cases, be as safely admitted as that of a vertebrate animal from its skeleton, or a mollusc from its shell.

If among them there are few strange and extinct types to marvel at, we must at least become lost in wonder at the extraordinary plant migrations they disclose, and the great changes in the relative positions of land and water, and of climate necessary for such migrations to have been practicable. The time is not yet when we can discuss profitably what these changes must have been, but at a future time we may be in a position to do so. We shall only show that during the vast lapse of time known as the Eocene, what are at present the shores of Great Britain supplied a common home for genera and species of Coniferæ which now only inhabit the remotest parts of the earth.

Of Cupressineæ, now only represented in England by the Juniper, we formerly possessed in our Southern Counties two Frenelas identical with species now exclusively confined to Australia and Tasmania, and a *Libocedrus*, which does not differ from the magnificent Incense-cedar of the Sierra Nevada. These give place in the Middle Eocene to a Cypress resembling the Funeral-cypress of China, while in the Irish area the lovely *Cupressus torulosa* of the Himalayas flourished in the greatest profusion.

There is now no representative of the fast-diminishing Taxodieæ living in Europe, nor within 5000 miles of Great Britain, but then every genus was represented within its area, for we not only had the *Glyptostrobus* of China, but the great Deciduous or Swamp Cypress of Florida. Both types of *Sequoia* seem to have formed part of our Eocene Flora, although some of our Eocene foliage is merely placed in the same genus with the Californian Red-wood, on account of the resemblance it bears to a French *Sequoia*. We had, however, two undoubted and beautiful species of the genus *Athrotaxis*, never previously found fossil, and now exclusively confined to the far-off Island of Van Diemen's Land, nearly 12,000 miles away. Further and repeated examination has confirmed the opinion that the Sheppey form is practically indistinguishable from *Athrotaxis selaginoides*, while the exquisitely preserved Hordwell specimens are identical with *Athrotaxis cupressoides*. While these were flourishing in England, the well-known *Cryptomeria* of Japan was thoroughly established in Ireland and Scotland.

The determinations of some of the Taxeæ are less satisfactory, for though *Ginkgo*, which abounded in Scotland, can always be identified, the Yew, though evidently of great

antiquity and probably present in many fossil Floras, has often been overlooked in consequence of its easily detached and insignificant fruits.

Of the PODOCARPEÆ we have, perhaps, several representatives belonging to more than one section of *Podocarpus*. The genus is a large one, and now almost confined to the Southern Hemisphere, and no species inhabits any country nearer to us than Tropical Africa. The species are still imperfectly known and resemble each other very considerably. The fossils cannot, therefore, in most cases, be absolutely assigned to existing species.

Two of our most graceful forms belong to the interesting tribe of ARAUCARIEÆ, supposed by many botanists to have been extinct in European latitudes since the Jurassic period. One of these is indistinguishable from *Araucaria Cunninghami*, the Moreton-Bay Pine, now limited to a somewhat restricted area in Northern Australia, and the other is the remarkable extinct *Doliostrobus*, uniting foliage something like that of the species just mentioned, and utterly unlike that of any living *Agathis*, with fruit that can only be placed with the latter genus.

Nothing new has come to light regarding the British Eocene species of the extensive Tribe ABIETINEÆ. The closed cones of two, if not three extinct species, have been found in the littoral sands of the Thanet Beds, and another in the estuarine mud of the London Clay. They formed no part of the inland Flora of the Middle Eocene so far as the vegetable débris deposited in the fresh-water clays of the Lower and Middle Bagshot Beds reveal. Not a vestige of them has ever been met with, not a solitary needle or scale among the myriads of fruits and seeds and leaves that our Bagshot series has yielded. But directly marine deposits are once more reached, as in the Bracklesham and Barton Beds, they again appear, and in great variety,[1] just as if they were fruits of the sea and formed an integral part of marine Faunas instead of a terrestrial Flora. It would almost appear that the Pine cones found stranded in the silts of our Middle Eocene seas had been drifted there from long distances and other lands. It is a mere conjecture, for they may equally have been brought down from the hills and uplands of the interior; but they certainly formed no part of the rich and varied forests whose falling leaves and fruits were floated and embedded at Bournemouth near to where they fell. They are equally absent in all the Upper-Eocene and Oligocene fresh-water beds, from Hordwell to Hempstead, and rich as many of these are in plant remains, Pine cones only reappear in one brackish-water mud bed of the Bembridge Marl.

In the Irish and Scotch Basalts, of Lower Eocene age, they occur in only one deposit of plants, out of many. But where they are present, at Ballypalady, they abound beyond every other plant; their bark, branches, and seeds, their needles, solitary and in clusters, and their cones open and closed, prove to how large an extent the neighbouring forests must have been composed of Pine trees. Except for a chain of accidental circumstances,

[1] A collection made during 1885 has shown that there are species at Highcliff distinct from those of the Bracklesham Beds.

—first that a basalt dyke had saved them from being denuded away; secondly, a railway was planned across them to avoid a gradient that would not now present any difficulty; thirdly, that they stood high enough above the general level to necessitate a cutting, the Ballypalady Flora would have remained unknown. Its preservation happily shows us that the remains of such gregarious and local trees as Pines and Firs may find their way in great abundance into the river-muds at one place, without betraying any trace of their presence in other not far distant muds, deposited apparently under the same conditions. But for accident we might have drawn a conclusion relative to the North-British Eocene similar to that we have just considered regarding the Eocene of our Southern Counties, but which would have been utterly erroneous. So unsafe must inferences ever be in this study when founded on negative evidence.

With regard to the leading species, *Pinus plutonis*, Baily, of Ballypalady, further research has shown a considerable resemblance between its cones and those of *P. Quenstedti*, Heer, of the Cretaceous Quadersandstein of Moletein,[1] the only difference being in the somewhat larger size of the latter, though the associated needles are thought to be in bundles of five. Other species as old resemble it, and its cylindrical form may be takenas a possible indication of coniderable antiquity.

FIG. 42.—Monstrous cone of *Abies Veitchii*, with bracts reverting into foliage leaves, and the axis prolonged into a branchlet with ordinary leaves. ('Veitch's Manual.')

None of the other genera of the Abietineæ are well represented, but a number of fragments are placed together in the genus *Tsuga*, simply because the more perfect cones resemble those belonging to living species of that genus more than any other. Sir Joseph Hooker has kindly reminded me that the generic characters upon which *Tsuga* is separated from *Abies* are not, and could not well be, apparent in the fossils. The determination is based on general likeness, and on such characters as are visible, and is not a strictly scientific one, nor one to which importance need be attached. The Pines, Firs, Larches, and Cedars belong to the most recently developed tribe of Conifers, and so far, none of their species had, even in the Eocene, assumed the precise forms met with at the present day.

[1] [Heer, "Beiträge zur Kreide-Flora," 1, 'Neue Denkschr. der Schweiz. Gesell.,' 1869.]

TABLE OF BRITISH EOCENE CONIFERÆ, WITH THEIR NEAREST EXISTING ALLIES, ARRANGED ACCORDING TO BENTHAM AND HOOKER'S CLASSIFICATION.

ORDER. CONIFERÆ.	Lower Eocene of Scotland.	Lower Eocene of Ireland.	English Eocene below the London Clay.	London Clay.	Lower Bagshot.	Middle and Upper Bagshot.	Upper Eocene and Oligocene.	Range of nearest existing representative.[1]
TRIBE I. CUPRESSINEÆ.								
Genus—*Callitris.*								
C. curta, *Bowerbank*, sp.	...	...	...	—	...	...	...	C. Australis and C. robusta, Australia.
C. Ettingshauseni, *Gardner*	...	...	...	—	...	...	...	C. Endlicheri, Australia.
Genus—*Libocedrus.*								
L. adpressa, *Gardner*	...	...	—	...	...	...	...	L. decurrens, California.
Genus—*Cupressus.*								
C. taxiformis, *Unger*, sp.	...	...	...	...	...	—	...	C. funebris, China-Japan.
C. Pritchardi, *Goepp.*, sp.	...	—	...	...	...	...	...	C. torulosa, Himalaya.
TRIBE II. TAXODIEÆ.								
Genus—*Taxodium.*								
T. europæum, *Brongt.*, sp.	...	...	—	...	...	—	...	T. heterophyllum, China-Japan.
T. eocænum, *Gardner*	...	...	...	...	...	—	...	T. distichum, Florida variety.
Genus—*Sequoia.*								
S. Tournalii, *Brongt.*, sp.	...	...	...	...	...	—	...	S. sempervirens?, California.
S. Shrubsolei, *Gardner*	...	...	...	—	...	...	...	S. gigantea, California.
Genus—*Athrotaxis.*								
A. subulata, *Gardner*	...	...	...	—	...	...	...	A. selaginoides, Tasmania.
A. Couttsiæ, *Heer*, sp.	...	...	...	...	...	—	—	A. cupressoides, Tasmania.
Genus—*Cryptomeria.*								
C. Sternbergii, *Goeppert*, sp.	—	—	...	...	...	...	...	C. japonica, China-Japan.

[1] Before the range of these British fossil species in other countries can be tabulated a revision of some of the determinations will be necessary. So long as all the Yew-like foliage is included in one species, *Sequoia Langsdorfii*, and all the Cryptomeria-like foliage in another, *S. Sternbergii*, very little progress in this direction can be made.

Order. CONIFERÆ.	Lower Eocene of Scotland.	Lower Eocene of Ireland.	English Eocene below the London Clay.	London Clay.	Lower Bagshot.	Middle and Upper Bagshot.	Upper Eocene and Oligocene.	Range of nearest existing representative.
Tribe III. TAXEÆ.								
Genus—*Ginkgo.*								
G. ? eocænica, *Ett. & Gard.*	...	...	...	—	...	...	...	G. biloba, China-Japan.
G. adiantoides, *Unger*	—	...	...	...	...	...	...	G. biloba, China-Japan.
Genus—*Taxus.*								
T. Campbelli, *Forbes*, sp.	—	...	...	...	...	...	...	T. adpressa, China-Japan.
T. Swanstoni, *Gardner*	...	—	...	...	...	...	...	T. cuspidata, China-Japan.
Tribe IV. PODOCARPEÆ.								
Genus—*Podocarpus.*								
P. eocænica, *Unger*	...	...	...	...	?	—	?	? P. andina, Chili.
P. Campbelli, *Gardner*	—	?						? P. falcata, Cape.
P. elegans, *Gardner*	...	...	...	...	—			Extinct.
P. argillæ-Londinensis, *Gardner*	...	...	...	—	...	...	...	P. elata, Australia.
P. incerta, *Gardner*	...	...	...	...	...	—	...	Extinct.
Tribe V. ARAUCARIEÆ.								
Genus—*Araucaria.*								
A. Goepperti, *Sternb.*, sp.	...	...	...	...	...	—	...	A. Cunninghami, Australia.
Genus—*Doliostrobus* (extinct).								
D. Sternbergii, *Goepp.*, sp.	...	...	...	...	...	...	—	Extinct.
Tribe VI. ABIETINEÆ.								
Genus—*Pinus.*								
P. macrocephalus, *Lindley and Hutton*, sp.	...	...	—	...	...	...	...	Extinct.
P. ovata, *id.*	...	...	—	...	...	...	...	Extinct.
P. Prestwichii, *Gardner*	...	...	—	...	...	...	...	? P. monticola, California.
P. Dixoni, *Bowerbank*, sp.	...	...	...	...	...	—	—	? P. laricio, Mediterranean.
P. Bowerbankii, *Carruthers*, sp.	...	...	...	—	...	—	...	?
P. Plutonis, *Baily*	...	—	...	...	...	...	...	? P. sinensis, China-Japan.
P. Bailyi, *Gardner*	...	—	...	...	...	...	...	Extinct.
Genus—*Tsuga.*								
T. Heeri	...	—	...	...	...	...	...	? T. Pattoniana, California.

If we examine this table, and contrast the Coniferæ of England in it with those of Scotland and Ireland, we discover indications of considerable differences in temperature. The varieties of *Callitris*, *Cupressus*, *Taxodium*, and *Araucaria* are such as are to be found growing in company near the water's edge in Madeira, whilst the more northern assemblage would be found there in grounds a couple of thousand feet above the sea. Farther north, in the Greenlandic Eocene, the North-British *Cupressus*, *Podocarpus*, and *Cryptomeria* give way in turn to a still more temperate assemblage, comprising the Red-wood, Deciduous Cypress, and probably Juniper, *Thuja*, *Cephalotaxus*, and Fir, while the Yew, Pines, and Ginkgo maintain their ground. There is thus little reason to believe that the climate of the Northern Hemisphere, though very much hotter during a part of the Tertiaries than at present, was then more uniform than now. An extensive migration of species, consequent on a considerable rise and fall of temperature, has caused the same plants in some cases to become embedded in very different latitudes, but it needs no argument to prove that all these widely separated deposits need not necessarily be of exactly the same age, and there is fortunately ample evidence in support of this. Not a single species of Conifer from either Ireland or Scotland, with the exception of Ginkgo, which first appears in southern Europe in the latest Miocene or possibly the Pliocene, has ever been met with in any beds of known Miocene age, and to maintain longer that the great Basaltic formation is in its entirety of the latter age, is simply to ignore the accumulated evidence.

The close connection of the Eocene Flora of the English basin with the present Australian Flora is another of the most obvious of the facts to be gathered from this table. The two species of *Frenela* (*Callitris*) and the *Athrotaxides*, known by their fruits, are purely Australian types, while the *Araucaria* and some of the Podocarps, though less perfectly known, are no less characteristically Australian. All these elements completely disappear from the Scotch and Irish Eocene basin, the plants of which seem mainly related to those of Eastern Asia. The essential difference between the Floras of our northern and southern basins, apart from the respective temperatures required by them, appears to lie in the fact that, whilst the former were almost restricted to types now indigenous to Eastern Asia, the latter possessed, in addition to these, types now peculiar to Australia and America.

In order to complete the Monograph as far as possible, the following Tables of Reference are appended, showing all the Coniferæ from British rocks of early Tertiary age recorded previous to the commencement of this work, and the position now assigned to them :

Names as published.	Status in this Monograph.
Cupressinites globosus, Bow.	Believed not to be Coniferous.
,, *elongatus*, Bow.	
,, *recurvatus*, Bow.	
,, *subfusiformis*, Bow.	

Names as published.	Status in this Monograph.
Cupressinites curtus, Bow.	United as *Callitris curta*.
,, *Comptonii*, Bow.	
,, *crassus*, Bow.	
,, *thujoides*, Bow.	
,, *subangulatus*, Bow.	
,, *corrugatus*, Bow.	Believed not to be Coniferous.
,, *sulcatus*, Bow.	
,, *semiplotus*, Bow.	
,, *tesselatus*, Bow.	
Cupressites taxiformis, Ung.	*Cupressus taxiformis*.
Sequoia Couttsiæ, Heer.	*Athrotaxis Couttsiæ*.
Sequoia Hardtii, Heer.	*Sequoia Tournalii*.
Taxites Campbelli, Forbes.	*Taxus Campbelli*.
Cupressites elegans, De la Harpe.	*Podocarpus elegans*.
Pinites macrocephalus, Lindl. & Hutton.	*Pinus macrocephala*.
Pinites ovatus, id.	*P. ovata*.
P. Bowerbankii, Carr.	*P. Bowerbankii*.
P. Dixoni, Bow.	*P. Dixoni*.
Pinus Plutonis, Baily.	*P. Plutonis*.
Cupressites MacHenrii, Baily.	*Cupressus Pritchardi*.
Sequoia Du Noyeri, Baily.	*Cryptomeria Sternbergii*.

Ettingshausen, in the list of Sheppey fossils published in the 'Proceedings of the Royal Society,' and already referred to, admits the following:

Callitris curta, Bow.	*C. recurvatus*, Bow.
C. Comptonii, Bow.	*C. subfusiformis*, Bow.
Solenostrobus subangulatus, Bow.	*C. globosus*, Bow.
S. corrugatus, Bow.	*Hybotha crassa*, Bow.
S. sulcatus, Bow.	*Sequoia Bowerbankii*, E. & G.
S. semiplotus, Bow.	*Pinus Sheppeyensis*, E. & G.
Cupressinites elongatus, Bow.	*Salisburia eocænica*, E. & G.

The only species which I am able to admit, of the entire number, are the first and the last on the list, but I add a new *Callitris*, *Podocarpus*, *Athrotaxis*, and *Sequoia*. Similarly in the list of the Alum Bay Flora the following occur:

Glyptostrobus europæus, Brong.	*Sequoia Langsdorfii*, Brong.
Callitris curta, Bow.	*Sequoia Couttsiæ*, Heer.
Cupressinites globosus, Bow.	*Podocarpus eocænica*, Ung.

I am thoroughly acquainted with the specimens on which the above are based, and I do not think they afford satisfactory grounds for supposing these *Coniferæ* to occur at Alum Bay. The beds there are singularly poor in *Coniferæ*, and all the known specimens of true Conifers belong to a single polymorphic species, which the attached fruit shows to be *Podocarpus elegans*.

Order.—GNETACEÆ.

The third order of Gymnospermæ, though comprising but three genera, is of the highest possible interest, for it possesses characters which serve in some respects to bridge the immense gap separating the Coniferæ from the angiospermous Dicotyledons. The three genera, *Ephedra*, *Gnetum*, *Welwitschia*, differ as much as even the various tribes in the Coniferæ from each other, and it is obvious that there can be no very close relationship between them, though sufficient likeness exists to allow them to be grouped in a single order. Saporta and Marion regard them as so many offshoots which have fallen out at widely different periods on the line of march, and remained stationary,—in other words, whose development has been arrested whilst their companions have progressed towards Angiosperms. At the same time, they believe them to be descended from a common ancestor of the *Taxeæ*, rather than that they are direct links between the existing *Coniferæ* and Angiosperms. Their origin must, in any case, be very remote, notwithstanding that so few traces of them have been discovered. Striated and articulated branches and scales have been described by Heer as *Ephedrites*, from the Jurassic of Siberia, and Saporta refers to analogous remains from the Inferior Oolite of the Côte d'Or. A more important discovery, however, is that of the female organ of an Ephedra-like plant in the Upper Carboniferous of the district of Autun, recently described by Renault in the 'Comptes Rendus' of the French Academy.

All the genera have their organs arranged in pairs, on a decussate plan, each alternate pair being at right angles to the last. Their embryos are dicotyledonous and stems jointed. Their wood has the usual Gymnospermous structure, and is marked with discs resembling especially that of *Phyllocladus*, though approaching in its greater complexity to that of Dicotyledons.

Ephreda seems by far the most primitive of the genera. Its species are all shrubs, without foliage leaves, and with green-jointed and repeatedly branching stems. A pair of opposite, minute, and partly sheathing leaves occur at each node, and the branches as well as the flowers proceed from their axils. The flowers are arranged in diœcious inflorescences, the male in catkins, and the female terminal on axillary stalks.

The former possess an involucre formed by a pair of bracts, partly soldered together, from the middle of which rises a staminal column bearing a number of anthers, or pollen chambers, corresponding to microspores and stamens. The pollen grains are divided across internally, according to Strasburger, by a membrane, as in the *Abietineæ*, only thinner. The female organs are protected by an integument of altered leaves, which form a rudimentary ovary. The ovule corresponds to that of the *Taxeæ*, and the endosperm produces but one archegonium. The fruit is a succulent cone, formed of two carpels, with a single seed in each.

In Gnetum the species are trees or creeping shrubs, with jointed and knotty branches and opposite entire leaves, which are not distinguishable from those of Dicotyledons. The flowers are monœcious, produced on cylindrical, stalked, and jointed catkins, and spring from the axils of the leaves. These catkins bear verticillate leaves, in the axils of which the flowers, both male and female, are agglomerated. The former are composed of a pair of bracts partially soldered together, forming an involucre from the middle of which rises a staminal column, composed of two staminal leaves supporting pollen chambers which correspond to the stamens of Dicotyledons, and are also in part the homologues of microspores. The female flower is fashioned of altered bracts which combine in pairs to form a double or even triple integument or perianth, the inner one being elongated like a style. The ovule is in structure that of a Gymnosperm, but enveloped like an Angiosperm, though the ovary is formed of undeveloped bracts, instead of carpellary leaves. It is solitary and the seed has an outer succulent coat.

Welwitschia is a most singular and abnormal plant, inhabiting the arid regions of South-west Africa, between the 14th and 23rd degrees of south latitude. Only a single pair of leaves, after the cotyledonary leaves, is developed, which eventually become leathery and split into shreds, attaining a length of six feet, and resting on the ground. The intervening woody stock thickens and hardens, assuming an obconical form, tapering rapidly towards the root, but never rising more than a foot above the ground, though the table-like top may spread horizontally several feet in diameter.

The circumference of the stem bears short-jointed branching flower-stalks, six to twelve inches in height, each fork terminating in a small oblong monœcious cone, scarlet when mature, under the decussate scales of which are flowers or seed. The female flowers have naked ovules not essentially differing from those of other Gymnosperms. The male flower is pseudo-hermaphrodite, containing anthers and an ovule, though the latter is always abortive or unfertilised. *Welwitschia*, through its male flowers, thus presents the nearest approach to Angiosperms met with in any Gymnosperm.[1] Only one species is known.

No trace of anything referable to *Gnetum* has been found in our Eocenes, unless the knotted and twisted stems found abundantly at Sheppey belong to it. A fruit from Sheppey, apparently a thin oval shell of the size of a small nutmeg kernel, was labelled "*Gnetum*" by Bowerbank; but it was in fragments when I saw it and cannot be restored. There are at present about fifteen species, confined to the tropics of Asia and America, with two outliers in Africa and Fiji.

The peculiarly-jointed and striated stems of *Ephedra* can, however, be picked out in abundance from the masses of pyritised twigs left by the tide at Sheppey, and there is no doubt that a species similar to that now living on the shores of the Mediterranean forms part of the Sheppey fossil Flora. I have also come across a stone perforated with

[1] See Sir J. D. Hooker in 'Trans. Linn. Soc.,' vol. xxiv; and Sach's 'Text-Book of Botany,' "Gnetaceæ."

twigs possessing all the characters of *Ephedra*, on the shores of Lough Neagh. Species have been described by Unger from Sotzka, by Heer from Switzerland, and by Ettingshausen from Häring.

Some thirty existing species of *Ephedra*, are known. They are erect or scandent, leafless, copiously-branching shrubs, abounding on the sandy seashores of Eastern Europe, North Africa, temperate and subtropical Asia, and extra-tropical America from Chili to California.

CEDAR OF LEBANON.
(Veitch's 'Manual.')

LIST OF EOCENE GENERA AND SPECIES

DESCRIBED IN THIS VOLUME.

Synonyms are in italics.

Adiantum formosum, p. 46.
Araucaria Goepperti, pp. 55—59, pl. xi, fig. 1 ; pl. xii.
„ *veneta*, p. 55.
Araucarites Goepperti, p. 55.
„ *Sternbergi*, pp. 55, 59, 85, 93.
Athrotaxis Couttsiæ, pp. 36—40, 90—91, pl. vi, except fig. 18 ; pl. x, figs. 6—9 ; pl. xxii, fig. 10.
„ subulata, p. 43, pl. xi, except fig. 6.

Callitris curta, pp. 21, 22, pl. ix, figs. 7—21.
„ Ettingshauseni, pp. 22—24, pl. ix, figs. 1—6.
„ *Comptoni*, p. 21.
Callitrites curtus, p. 21.
„ *Comptoni*, p. 21.
„ *thujoides*, p. 21.
Chamæcyparites Hardtii, p. 40.
Cryptomeria Sternbergii, pp. 85—89, pl. x, figs. 2, 3, 10—13, pls. xx, xxi
Cupressinites Comptonii, p. 21.
„ *corrugatus*, p. 21.
„ *crassus*, p. 21.
„ *curtus*, p. 21.
„ *elongatus*, p. 20.
„ *globosus*, p. 20.
„ *recurvatus*, p. 20.
„ *semiplotus*, p. 21.
„ *subangulatus*, p. 21.
„ *subfusiformis*, p. 20.
„ *sulcatus*, p. 21.
„ *tesselatus*, p. 21.
„ *thujoides*, pp. 20, 21.
Cupressites curtus, p. 21.
„ *elegans*, p. 50.
„ *Mac Henrii*, p. 82.
„ *racemosus*, p. 30.
„ *taxiformis*, pp. 26, 51.

Cupressoxylon Pritchardi, p. 82.
Cupressus Pritchardi, pp. 82—84, pl. xvi, figs. 8 and 9; pl. xviii, fig. 1; pl. xix.
„ taxiformis, pp. 26—28, pl. i, figs. 1—13; pl. v, figs. 13, 14; pl. vii, fig. 8; pl. ix, figs. 22—26, 28—30.

Doliostrobus Sternbergii, pp. 93—97, figs. 36, 37, pl. xxii, except fig. 10, pl. xxiii.

Ginkgo adiantoides, pp. 99, 100, pl. xxv.
„ *biloba*, p. 99.
„ eocænica, pp. 46, 47, pl. ix, figs. 31—34.
„ *primordialis*, p. 46.
Glyptostrobus europæus, pp. 30, 50.

Hybothya crassa, p. 21.

Libocedrus adpressa, p. 25, pl. ii, figs. 17—20.
Lycopodites squamatus, p. 59.

Pinites Bowerbankii, p. 68.
„ *Dixoni*, pp. 66, 68.
„ *macrocephalus*, p. 63.
„ *ovatus*, p. 65.
„ *Pritchardi*, p. 82.
Pinus Bailyi, p. 73, pl. xv, figs. 2, 5, 9; pl. xvii, fig. 4.
„ Bowerbankii, pp. 68, 69, fig. 28, pl. xiii, figs. 6, 9; pl. xiv, figs. 3, 8.
„ Dixoni, pp. 66—68, fig. 27, pl. xiii, figs. 1, 2, 4, 5, 8.
„ *Graingeri*, p. 69.
„ *MacClurii*, p. 74.
„ macrocephalus, pp. 63, 64, pl. xiv, figs. 1, 2, 6, 7.
„ ovata, p. 65, pl. xiv, figs. 4, 5.
„ Plutonis, pp. 69—72, pl. xv, figs. 1, 3, 4, 6, 7, 8; pl. xvi, figs. 5—7, 17; pl. xvii, except fig 4, pl. xviii.
„ Prestwichii, pp. 65, 66, pl. xiii, fig. 3.
„ *sheppeyensis*, p. 68.
Podocarpus argillæ-Londinensis, p. 52, pl. ix, figs. 35, 36.
„ Campbelli, pp. 97—99, pl. xxvi.
„ elegans, pp. 50, 51, pl. viii, figs. 1—16.
„ eocænica, pp. 48—50, pl. ii, figs. 6—15.
„ incerta, p. 52, pl. ii, figs. 1—5.

Salisburia adiantoides, p. 99.
„ *borealis*, p. 99.
„ *eocænica*, p. 46.
„ *Procaccinii*, p. 99.
Sequoia *Bowerbankii*, p. 12.
„ *Couttsiæ*, pp. 36—40, 50, 90.
„ *Du Noyeri*, p. 85.
„ *Hardtii*, p. 40.
„ *Langsdorfii*, pp. 41, 50.
„ Shrubsolei, pp. 91, 92, fig. 35.
„ *Sternbergi*, pp. 55, 85, 93.

Sequoia Tournalii, 40.
„ Whymperi, pp. 38, 39, pl. vi, fig. 18.
Solenostrobus corrugatus, p. 21.
„ *subangulatus*, p. 21.
„ *sulcatus*, p. 21.
„ *semiplotus*, p. 21.
Steinhauera subglobosa, p. 55.

Taxites acicularis, p. 26.
„ *Campbelli*, p. 41.
„ *Langsdorfii*, pp. 41, 102.
„ *Rosthorni*, p. 51.
„ *Tournalii*, p. 40.
Taxodites europœus, p. 30.
Taxodium *dubium*, p. 36.
„ eocænum, p. 31, pl. vii, figs. 1—8.
„ europæum, pp. 30, 31, 92, 93, pl. iii, figs. 1—9; pl. iv, figs. 1—8, pl. xxiv.
„ *œningense*, p. 30.
Taxus Campbelli, 101, 102, pl. x, fig. 1; pl. xxvii, figs. 1—3.
„ Swanstoni, p. 89, pl. x, figs. 4, 5.
Tsuga Heerii, pp. 74—76, pl. xvi, figs. 1—4, 10—16.

Zamia macrocephala, p. 63.
„ *ovata*, p. 65.
Zamiostrobus Henslowii, p. 63.
„ *macrocephalus*, p. 63.
„ *ovatus*, p. 65.
Zamites macrocephalus, p. 63.
„ *ovatus*, p. 63.

GENERAL INDEX.

PAGE

Abies 11, 12, 60, 61, 128
„ canadensis 60
„ Douglasii 16
„ excelsa 16
„ Menziesii 16
„ nigra 60
„ pectinata 16
„ sibirica 60
Abietineæ . . 60, 125, 128, 129, 135
Abyssinia 24
Actinostrobus 18
Africa, tropical vegetation . . . 98
Agathis . . 52, 53, 54, 96, 124, 125
„ robusta 54
Age of Basalts 79
„ Coniferæ 16
Aix, gypsum of . 4, 12, 19, 20, 24, 40, 49, 50
„ dry Eocene climate of . . . 6
Aix-la-Chapelle, Cretaceous Flora of, 2, 11, 17, 48, 53, 132, 133
Alais 94
Alaska . . . 30, 32, 42, 44
Albertia 11, 125
Alder cones, supposed to be Sequoia . 12
Algæ 108
Alps, Coniferæ of . . . 16, 60
Altitudes at which Coniferæ grow . . 18
Alum Bay . . 12, 22, 41, 48, 49, 50
„ supposed pine scales from . . 13
„ Conifers erroneously included in Flora of . . . 12, 51
Amber Beds . . 11, 19, 20, 24, 53, 60. 61
„ value of 60

PAGE

Amboyna pine 54
America . 31, 39, 42, 44, 48, 60, 98, 103
„ and Europe, former connection of, strengthened by Coniferæ . . 6, 13
„ Tertiaries of 5
„ tropical Flora of . . . 2
Andes 24
Anemia subcretacea 93
Angiosperms 110
Annularia 114
Anomalous wood from Silurian formation . 10
Antheridia 109
Antherozoïds 109
Anthracotherium 94
Antrim, age of fossil plants of . 2, 3, 106
„ Coniferæ of 12, 38, 42, 48, 69, 74, 77, 82, 85, 89
Apennines 71
Aquitanian strata 5, 50
Araucaria . 11, 12, 13, 52, 53, 54, 57, 94, 115
„ Bidwillii . . . 125, 127
„ Cookii 125
„ Cunninghami 54, 56, 58, 87, 95, 125, 135
„ excelsa . . . 55, 125, 127
„ Goepperti . . . 55, 59, 89
„ imbricata . . . 55, 57
„ veneta 55
Araucarieæ 126, 135
Araucarites Brodiei 127
„ Goepperti . . . 55
„ Nordenskioeldi . . . 53
„ Phillipsii . . . 127
„ Pippingfordensis . . 127

	PAGE
Araucarites sphærocarpus	127
„ Sternbergii	55, 57, 93
Archæocalamites	114
Archegonium	109, 121
Arctic Flora	1, 98
„ Floras, mingling of	2
„ „ northern origin of	2
„ fossil Coniferæ of	29, 32, 34, 44, 45, 48, 61
„ Circle, unfossiliferous rocks of early Eocene age	2, 126
„ currents, effects of	6
Arcueil	68
Ardennes, Wealden of	11
Ardtun Head	42, 77, 88, 98, 99, 100, 103, 104
„ relative age of	106
Argyll, Duke of	42, 99, 100, 103
Armissan	5, 19, 24, 25, 38, 41, 50, 51, 120
Asia, plants of east coast	2
„ in Europe	13
Asterophyllites	114
Astromyelon	114
Atane, Coniferæ of	12, 19, 46
Atanekerdluk	30, 32, 100
Athrotaxis	29, 43, 54, 93, 94, 96, 127, 134
„ Couttsiæ	90
„ cupressoides	91, 134
„ selaginoides	43, 58
„ subulata	43
Athrotaxites	11
Atlantis, reality of	7
Atlas	61
Australia, Flora of, in England	7, 13
„ „ north-east coast	2, 20, 126
„ Miocene of	20
„ Coniferæ of	45, 54, 55
Austria	71
„ Eocene of	42
Austro-Hungary	24
Autun	115
Auvergne, Tuffs of	5
Bacton, Pliocene of	61, 82
Baieria	45, 126
Baily	81, 84
Ballintoy	81
Ballypalady,	61, 69, 70, 73, 74, 81, 82, 85, 89, 136
Baltic "Miocene"	32, 39, 44, 46
Banksland	75
Barbary	24
Barton	59
Basalt	69, 73, 74, 77, 82, 85, 89, 104
„ thickness of	77
„ extent of	77, 78
Bauxite	81
Bayreuth	45
Belfast Museum	70
„ Naturalists' Field Club	90
Belgian plants	4
Belleu, Grès de	4
Bembridge Beds	39, 59, 66, 68, 91, 93, 95, 96
„ Limestone	7
Bennettites	120
Bentham and Hooker	17, 20, 52, 60, 62
Bhotan	44
Bilin	24, 25, 39, 44, 50, 58, 98
Binney	115
Biota	28
Blackdown Beds, Coniferæ of	11, 34, 132
Bohemia	20, 132
Bolander, Prof.	33
Bonn	24
Bonnieux	4, 120
Borneo	44, 59
Bornia	114
Bourg, section through Basalts	103
Bournemouth,	4, 26, 30, 31, 36, 39, 40, 48, 52, 56
„ supposed remains of Pinus there	13
Bovey Tracy	4, 6, 36, 40, 90
Bowerbank	12, 19, 20, 69, 92
„ Collection in British Museum	46
Brachyphyllum	29, 125, 126
Bracklesham	59, 66, 67, 68
Brazil	55
Break, extent of, between Eocene and Chalk	130
Brisbane	25, 55, 56, 58
Britain, former westward extension of	7
British Association, grant from	103
Britten, Dr.	98
British Museum	38, 42, 46, 58, 66, 99, 102
British North America, Pine forests of	60
Brives, Grès de	4
Bromley	3, 4, 12
Brongniart, Ad.	101, 112, 113, 115
„ classification of	10

PAGE

Brown-coal 42, 60, 98
Bryon 114
Buckland, Dean, on Cycads . . . 14
Bulimus 7
Burntisland 115

Calamites 113
Calamodendron 113
Calcaire grossier 4, 68
Caledonian Isles 55
California, 24, 26, 28, 29, 31, 44, 46, 53, 84, 87, 100
Callitris 1, 2, 17, 19
„ list of . . . 20, 21
„ australis 22
„ Brongniarti 24
„ curta 21
„ Endlicheri 23
„ Ettingshauseni . . . 22
„ Heerii 24
„ quadrivalvis . . . 18, 24
„ robusta 22
Canada 66
Canna, fossil plants of . . 4, 77, 85, 87
Cannophyllites 117
Cantal, Cinérite de 5
Canterbury 64
Cape of Good Hope 98
Carboniferous formation . 10, 44, 45, 115, 120
„ structure of Cryptogams of . 112
Cardiocarpus 118
Carruthers, 11, 34, 43, 53, 61, 64, 65, 66, 68, 84, 98, 113, 115, 126, 127
„ on Cycads . . . 14
Carsaig, Tertiary gravel of . . . 105
Cedar 16, 60
Cedroxylon Worthingense . . . 61
Cedrus . . . 11, 60, 61, 128
Celery-leaved pine 44
Cembra section of Pinus . 11, 69, 74, 128
Cenomanian 132
Cephalotaxus . . . 29, 50, 98
Céreste 4
Ceyssac, Marnes de 5
Chalk 128, 130
„ conditions of deposition . . 130
Chamæcyparis . . . 18, 19

PAGE

Chamæcyparis Hardtii . . . 19
Chamæcyparites Hardtii . . 35, 40
Chambre pollinique 115
Characeæ 108
Cheirolepis 127
Chiavon 57, 58, 96
Chili, Conifers of . 16, 44, 48, 55, 92, 98
Chilian Araucarias 16
China 24, 26, 28, 29, 31, 44, 46, 53, 84, 87, 100
Chlorophyll 108
Chousan, Isle of 87
Coast Range 33
Coemans 11, 62
Columbea 11, 54
Comparison of Antrim and Mull Floras . 80
Cones, forms of 11
Confervæ 108
Conifers, difficulty in determining . . 13
Coniferous forests, characters of . . 16
Corda 64
Cordaites . . 117, 118, 119, 123, 125, 126
Corea 47
Corpuscula 116, 121
Cossart, Leland . . . 56, 94
Climate of the Middle Eocene . . 6
Cretaceous Flora of Kome . . 11, 29
„ Conifers, 11, 17, 29, 36, 44, 55, 60, 61, 91, 126, 127, 130, 133
„ „ Germany . . 53
Croydon 4, 91, 93
Cryptogams in the Carboniferous strata . 112
Cryptomeria 2, 9, 59, 84, 94, 102, 125, 127, 134
„ araucarioides . . . 87
„ elegans 87
„ Japonica . . 58, 86
„ Sternbergii . . 84, 85, 95
Cunninghamia . . . 52, 53, 125
Cunninghamites . . . 53, 133
Cupressineæ . . 12, 17, 76, 127, 128, 134
Cupressinites crassus 19
Cupressites elegans 50
„ Mac Henrii . . . 82
„ racemosus . . . 30
„ taxiformis . . . 26
Cupressoxylon Pritchardi . . 17, 82
Cupressus 25
„ fastigiata 86

	PAGE
Cupressus funebris	28, 83, 86
„ macrocarpa	27
„ nutkaensis	86
„ obtusa	83
„ Pritchardi	82, 84
„ sempervirens	27, 83
„ taxiformis	26, 51, 83
„ torulosa	18, 19, 83, 84, 134
Cycadaceæ	11, 12, 14, 118
Cycads	111, 113, 115, 123
Cycas, structure of stem, &c.	118, 119, 120
Cyparissideum	11, 17, 29
Cypress	16, 18, 102, 134
Cyprus, Conifers of	61
Czekanowskia	45
Dacrydium	43, 44, 59, 86, 94, 124
„ araucarioides	58
„ balansæ	43
„ cupressinum	44
„ cupressifolium	51
„ elatum	44
„ Franklini	44
„ laxifolium	44
„ taxifolium	43
Dacrycarpus	48, 51
Dadoxylon	112, 115, 117, 124
Dakota, Cretaceous Flora of	2, 12, 80, 91
Dammara (*see* also Agathis)	11, 54
Dammarites	54
Darwin on fertilisation of Coniferæ	9
Dawson, Sir W. J.	5, 113, 114, 115
De Candolle on Coniferæ	16
Deccan, extent of Basalts of	77
Deciduous cypress (*see* Taxodium distichum)	30
De la Harpe on Eocene Floras of England	27, 51
Delta of Eocene river in England	7
Denudation in Scotland	79
„ of the Chalk	132
Deodar forests	16
Desmids	108
Determination of leaves, difficulties attending	8
Devonian, American Coniferæ of	115
Diatoms	108
Disco, fossil plants of	38, 100
Dimensions attained by Coniferæ	16
Diminution of Coniferæ	16
Dismal Swamp	32
Dixon's Geology of Sussex	59, 61, 67, 68
Dolerophyllum	116
Doliostrobus Sternbergii	93, 103, 135
Douglas spruce	42
Dowker	64
Dulwich, Flora of	4
Durfort, Marnes de	5
Dwarfed Coniferæ	18
Dyer, Thiselton	53, 55
Dykes in Basalt	77, 105
Earliest known plants	10
Echinostrobus	17, 29, 127
Economical value of Coniferæ	17
Eigg, Scur of	78
Ekkorfat, fossil Coniferæ from	34
Elate austriaca	74
Encephalartos	14
„ Gorceixianus	120
Endlicher	74
Endosperm	115
Engelhardt	98
Eocene delta	7
„ Floras below London Clay	1
„ „ migrations of	2
„ „ subtropical and temperate	2
„ „ supposed absence of round the North Pole	3
„ river, extent of	7
Ephedra	141, 142
Equisetaceæ	109
Equisetum	104, 109, 114
Ettingshausen	44, 46, 58, 71, 92, 96, 98
„ list of Sheppey fruits	12, 13
„ „ Alum Bay plants	22, 51
Eubœa, fossil plants of, *see* also Koumi	30, 120
Eupodocarpus	48
Europe and America, former connection of	6
„ former contour of	7
Eutassa	11, 54
Evolution of plants	9, 10
Faröe Isles	77, 78
Faversham	65
Ferns	109
Fiji Isles	54, 92, 98
Fir	60

PAGE

Fisher, Rev. O. 67
Fissure eruptions 78
Fitzroya 18
Florida 32, 44
Florideæ 108
Flowers of Coniferæ 15
Folkestone, fossil cones from . 11, 127
Forbes, Prof. E., on fossil plants . 80, 101
Forests of Coniferæ, distinguishing characters of 16
Fortune 87
Fossil fruits and seeds of London Clay . 20
France, plant beds of . . 4, 5, 35
„ fossil Coniferæ of . . 12, 42
Frenela 18, 134
Fucoids 108
Funeral Cypress 134
Fungi 108

Gardener's Chronicle . . 63, 72
Garges, gypsum of 4
Gault, Coniferæ of, 11, 29, 34, 60, 62, 127, 128
„ deposition of 131
„ of Hainault . . . 61, 62
Geikie, Archibald . . . 77, 78
Geinitzia 29, 133
Gelinden, Limestone of . . . 4
Geological Survey of Ireland . . . 81
„ Magazine . . . 127, 128
Germany, Cretaceous deposits of . . 11
Giant's Causeway 81
Ginkgo . 10, 13, 42, 44, 102, 115, 125, 126
„ adiantoides . . . 46, 99, 100
„ biloba . . 46, 99, 122, 123
„ concinna 45
„ digitata 11
„ eocænica 46
„ primordialis . . . 46, 100
Ginkgophyllum . . 124, 125, 126
Glenarm 81, 85, 88
Globigerina ooze 131
Glyptolepis 53, 125
Glyptostrobus . . 12, 26, 29, 30
„ bilinicus . . . 31
„ europæus . . 30, 31
„ „ (also Taxodium) . 50
„ gracillimus . . . 91

PAGE

Glyptostrobus heterophyllus . 31, 103
„ Ungeri . . 31, 39
Gnetaceæ 141
Gnetum 141, 142
Goeppert . . . 57, 60, 84, 96, 101
Goldenberg on Lepidodendron . . 112
Gordon's Pinetum . . 17, 20, 47, 100, 102
„ Herbarium 28
Grand'Eury . . . 112, 113, 115, 116
Greenland, Flora of, 2, 6, 19, 24, 32, 35, 36, 38, 39, 42, 46, 58, 61, 70, 75, 100
„ Cretaceous Flora of 2, 11, 61, 62
„ Tertiary Floras not Miocene . 3, 80
„ causes of changing climates . 7
Greensand 29, 127, 131
Grès du Soissonnais 50
„ de la Sarthe 50
Grey Chalk 132
Guatemala 26
Gurnet Bay . . 4, 36, 40, 66, 67, 93, 95, 103
Gymnosperms, antiquity of . . . 9
„ evolution of . . . 9
„ number of Tertiary species . 12
„ position of . . . 9
Gymnospermous wood . . . 53

Hainault, Cretaceous Flora of . 11, 61
Hampshire basin, formerly a delta . . 7
Häring, flora of 19, 24, 35, 50, 57, 92, 96, 98
Havre, Lower-Cretaceous Coniferæ of . 11
Hebrides 79
Hector 55
Heer, 3, 12, 18, 19, 31, 32, 34, 38, 42, 44, 49, 53, 58, 70, 75, 84, 87, 90, 92, 96, 98, 100
„ on the Kome beds . . . 12
„ the fossil plants of Mull . . 80
„ and Pengelly 91
Hemlock spruce 73
Hempstead, Flora of . . 4, 36, 39, 59, 90
Henslow 64
Hepaticæ 108
Herne Bay, Flora of . . . 4, 65
Highcliff, fossil cones at . . 67, 68
Himalaya, Coniferæ of 16, 61, 62, 66, 84, 128
Hindustan 48, 98
Hong Kong 71
Hooker and Bentham . . . 47

PAGE

Hooker, Sir J. 1, 10, 23, 28, 32, 34, 45, 113, 115
„ opinion on value of fossil Coniferæ . . . 13
Hordwell, Flora of . . . 4, 48, 90
Horsetails, also Equisetum . . . 110

Ice, effect on climates of floating . . 6
Iceland, climate of, affected by floating ice . 6
„ fossil Floras of . 3, 5, 35, 59, 61, 77
„ Basalts of 79
Import of Coniferous wood . . . 17
Incense-cedar, also Libocedrus decurrens, 25, 42, 134
India, Coniferæ of 44
„ Jurassic Coniferæ of . . . 53
„ in Eocene times . . . 7
Inferior Oolite . . . 127, 128
Infra-lias (*see* Rhætic) . 120, 125, 127
Inolepis . . . 11, 17, 29
Iron-ores of Ireland 81
Isoëtes 113
Isotherms 6

Jamieson, W. 81
Japan, 24, 29, 30, 44, 48, 53, 61, 73, 84, 87, 90, 98, 102
Java 51, 62, 87
Jeanpaulia 45
Jesso, Isle of 102
Jointed Yews 43
Judd 77
Juniperus 18, 128
„ canadensis 18
„ recurva 86
„ rigida 19
„ uvifera 18
Jurassic Coniferæ, 11, 17, 29, 45, 60, 61, 125, 126, 127, 128

Kaipara Harbour 54
Kauri pine, *see* Agathis robusta, also Dammara 54
Keeping 69
Kew Herbarium . . 28, 31, 90, 98
Kimmeridge Clay, pine cone from . . 128
Kinahan 81
Komeschichten, Cretaceous Flora of the 11, 12
„ Cycads of . . . 14
Coniferæ of . 17, 29, 44, 46
Koumi, *see* also Eubœa . . 50, 72, 120

PAGE

Lagenostome 115
Land Mollusca 7
Languedoc 4
Lapland 62
Larch 16, 60, 74
Larix 60, 61, 128
„ microcarpa 60
„ sibirica 60
Lausanne 70
Lebanon 61
Leoben, Flossil Flora of . 24, 42, 68, 71
Lepidodendron . . . 112, 114
Lepidostrobus 125
Leptostrobus 29
Lesquereux . . . 12, 31, 53, 91
Lewisham 4
Lias 123, 126
Liassic Gymnosperms . . 11, 53
Libocedrus 12, 18, 24
„ adpressa 25
„ andina 24
„ chilensis 24
„ decurrens . . . 18, 25
„ salicornioides . . 24, 25
Lignite of Ireland 81
Lignitic formation of North America . 31, 39, 42
Limits of growth of Coniferæ . . 16
Lindley, classification by . . 9, 43
Lindley and Hutton's 'Fossil Flora' . 14, 64
London Clay . . . 4, 52
„ „ Coniferæ 20, 22, 52, 61, 68, 91
„ „ increase of temperature during the deposition of . . 6
London Basin, formerly a delta . . 7
Londonderry 77
Longevity of Coniferæ . . . 16
Lough-Neagh deposits . . 82, 92
Lower-Greensand plants . . . 11
Lycopodiaceæ . . 111, 112, 114, 121
Lycopodites squamatus . . . 59
Lyme Regis 65

MacClintock 38
MacClintockia . . . 81, 89
Mackenzie River . . . 30, 39
Macrospores 110

	PAGE
Madagascar	19
Madeira	35, 42, 56, 90
Magnolia	71, 70, 132
Maidstone	11
Malaya	54
Mammoth Grove	59
Manosque	5
Marion (also Saporta and Marion)	94, 96
Maritime Pine	61
Marseilles, basin of	5
Marsilia	110, 115
Massalongo	42, 57, 99
Massive eruptions	78
Masters, Maxwell	47
Mayencian stage	4, 35
Mediterranean, former extent of	7
„ Coniferæ of	64, 68, 71, 92
Melville Isle	120
Ménat, Lower Miocene of	5, 24
Mexico	26, 30, 61, 62, 69, 73
Meximieux	5, 44
Microcachrys	43
Microspores	110
Migrations of plants	7, 134
Miocene Coniferæ	32, 35, 39
„ deposits of France	5, 46
„ „ Germany	42, 61
„ „ Greenland, *see* Greenland.	
„ „ Italy	42, 46
„ Flora, origin of	1
„ „ migration of	2
„ „ supposed, near Pole	3
Mississippi	47
Moletein	136
Mollusca, land	7
Monod	24
Mont Charray, Upper Miocene of	5
Monte Colle	58
Monte Promina	58, 87
Moore, C. (Sydney)	59
Moreton Bay	58
„ Pine	135
Moriconia	24
Mount Atlas	24
Mull, age of fossil plants	2, 3
Mull, 13, 35, 41, 48, 77, 79, 85, 99, 100, 101, 103	
Museum of Practical Geology	42

	PAGE
Nageia	47
Nathorst	128
Neocomian	60, 61, 62, 128, 131
Neotropical Flora in England	7
Neustadt	133
Newberry	98, 103
New Caledonia	20, 44, 48, 51, 54, 55, 98
Newhaven	3, 4
New Hebrides	54, 55
New Holland	22
New Zealand	24, 44, 54, 55
Nilssonia	120
Noeggerathia	10, 45, 115
„ foliosa	120
Norfolk Island	55
North-African Coniferæ	19
North America	29, 32, 44, 61, 73
Northern limits of Coniferæ	18
North Sea, former isolation of	7
Norway	128
Nostochineæ	108
Oeningen	39
Oldest plants	10
Oligocene	4, 5, 39, 48, 58, 91
Olliver	23, 98
Onoclea	102, 104
Oolites	128
Oospore	109
Ophioglosseæ	109
Oregon	61, 66, 78
Pachyphyllum	11, 53, 96
Palæocyparis	128
Palæozoic Coniferæ	126
Palæotherium, zone of	4
Paleocene	4
Palissya	53, 126, 127
Palmelleæ	108
Paloplotherium minus, horizon of	94
Paris Basin, plant beds of	4
Patagonian Coniferæ	18, 47
Patoot	96
Pattorfik	29, 34
Pelobius	108
Permian, 10, 11, 29, 45, 116, 117, 120, 125, 126, 127	

PAGE

Persia 62
Peyriac 49, 50
Philadelphia Exhibition, Coniferæ at . . . 18
Philippines 57
Phœnicopsis 45
Pherosphæra . . . 43, 44
Phyllocladus 43, 44, 124
Phyllostrobus 128
Picea 60, 61, 128
„ grandis 16
„ nobilis 16
Pinaster . . . 11, 62, 69, 73, 128
Pine 60
Pine-barrens 16, 60
Pine-needles from Reading . . . 92
Pinites cryptomerioides . . . 35
„ depressus 128
„ Dixoni . . . 66, 68
„ macrocephalus . . . 63
„ ovatus 65
„ Pritchardi 82
Pinnularia 114
Pinus . . . 11, 12, 60, 62, 102
„ austriaca 72
„ Bailyi 73
„ Bowerbankii 68
„ cembra . . . 60, 62, 69
„ Crameri 61
„ Credneri 12
„ Defrancei 68
„ Dixoni 66
„ excelsa . . . 62, 66
„ Graingeri 69
„ halepensis . . . 68, 71
„ Hampeana 72
„ hepios 72
„ hordacea 68
„ insignis 63
„ koraiensis 63
„ Lambertiana . . . 16, 62
„ Lardyana 70
„ laricio . . . 68, 71, 72
„ MacClurei 75
„ macrocephalus 63
„ monticola . . . 66, 74
„ ovata 65
„ palæo-laricio 72
Pinus patula 73
„ peuce 66
„ pinea 64
„ Plutonis . . . 69, 73, 74
„ Prestwichii 65
„ pyrenaica 68
„ Quenstedti 136
„ Russeliana 69
„ sheppeyensis 68
„ sinensis 71
„ strobus . . . 62, 66
„ sylvestris . . . 60, 62, 67
Pisolitic iron-ore, formation . . . 81
Pitys Haidingeri 68
Plane tree 1
Platanites aceroides 104
Pliny 17
Pliocene deposits of France . . 5, 19, 44, 46
„ „ Tuscany . . 30
Podocarpeæ 47, 122, 135
„ distribution of . . . 98
Podocarpus . . 13, 16, 47, 102, 124, 135
„ andina . . . 50, 51
„ argillæ-Londinensis . . 52
„ Campbelli . . . 97
„ cupressina . . 51, 98
„ elata . . . 48, 52
„ elegans 50
„ elongata 50
„ eocænica . . . 48, 49, 98
„ falcata . . . 50, 98
„ incerta 52
„ gracilis 49
„ hæringiana . . 49, 98
„ micronulata . . . 49
„ neriifolia 97
„ Novæ-Caledoniæ . . . 50
„ plana 49
„ proxima 49
„ taxiformis . . . 51
„ taxites 49
„ tenuifolia . . , 51
„ Thunbergii . . . 98
Pollen grains 116
Polymorphism in Coniferæ . . . 127
Poole 41
Poroxylon 115, 118
Porte Molle 55

PAGE

Portlock 81
Portugal, Cretaceous Beds of . . 18, 29
Prestwich 66
Progymnosperms . . . 114, 116
Protamœba 108
Prothallium 110
Protista 108
Protonema 109
Protophytes 108
Provence 4, 19
Pseudotsuga 60, 61
Psygmophyllum . . . 45, 167
Pterophyllum 120

Quadersandstein 136
Quedlinberg 133
Queensland 54, 98

Radaboj 24
Ralligen 50
Ravine at Ardtun 105
Reading, fossil Flora of . 1, 3, 4, 91, 92
Red-Cedar 18
Redwood . . . 33, 42, 101, 134
Renault . . . 112, 113, 115, 116
Resin 17
Retinospora filifera 28
Rhætic . . . 45, 120, 127, 128
Rhamnites 104
Rhizocarpeæ 110
Richardson 65
Richmond River 58
Riesengebirge, Pine zones of . . . 63
River deposits, Eocene, . . . 7
„ of Ardtun . . . 104
Royal Society . . . 76, 103, 106

Sachs . . . 119, 121, 124, 125
Sagor 18
Salisburieæ 114
Salisburia (also Ginkgo) . . 13, 44
„ adiantifolia macrophylla . . 100
„ adiantoides 99
„ eocænica 46
„ Procaccinii . . . 99
„ Samland, in . 20, 53, 60, 100
Santa Cruz 42

PAGE

Saporta, 1, 4, 9, 10, 19, 24, 34, 38, 40, 44, 45, 47, 53, 92, 108, 109, 112, 113, 116, 125, 127, 128
Saxegothea 47, 124
Scania 128
Sciadopitys 52, 75
Schimper . . 4, 11, 29, 34, 45, 54, 55
Schizolepis 125, 127
Schœnegg 24
Sclerophyllina 126
Sclerotites salisburiæ . . . 99
Scotch fir 61
Secondary Coniferæ 11
Seeds of Gymnosperms . . 15, 17, 121
Selaginella . . . 110, 113, 121
Selby on Coniferæ 16
Senonian 96
Septarian concretions in Bembridge Limestone 96
Sequoia . 12, 16, 29, 33, 57, 127, 133, 134
„ acuminata 35
„ Bowerbankii . . . 12
„ brevifolia . . . 35, 42
„ Couttsiæ . . 12, 35, 36, 38, 50, 90
„ Du Noyeri 85
„ fastigiata 34
„ gigantea . 34, 35, 39, 58, 90, 91
„ Hardtii . . 27, 35, 40, 42
„ Langsdorfii, 12, 35, 39, 41, 50, 90, 101, 102
„ polymorpha . . . 26, 38
„ Reichenbachii . . . 34
„ rigida 34
„ sempervirens . 33, 35, 38, 41, 42
„ Shrubsolei 91
„ Smithiana 34
„ Sternbergi 12, 35, 39, 55, 59, 85, 87, 93
„ subulata 34
„ Tournalii . . . 40, 42
„ Whymperi . . . 35, 39
Sézanne 4
Shanklin, fossil cones from . . . 11
Sheppey 4
„ alder cones mistaken for Sequoia . 12
„ Coniferæ of . 22, 43, 46, 52, 68, 70, 91
„ fruits of 20
Shrubsole 52, 92
Siberia . . . 45, 60, 62, 128
„ larches in 16

PAGE

Siebold 87
Sierra Nevada 33
Sigillaria 112, 114
Silicified wood of Lough Neagh . . 82
Silver fir 16
Silurian plants 10
Sinigaglia . . . 24, 25, 36, 39
Skye 79
Smith, A'Court . . 67, 93, 96, 103
Soissonais, Grès du 4
Solenhofen, Coniferæ of . 11, 29, 53, 62, 127
Somersetshire, Oolitic Coniferæ of . . 53
Sotzka 50, 58, 92
Southern limits of Coniferæ . . . 18
South of France, Coniferæ of . . 12
South Africa 19
Sphenolepis 127
Sphenolepidium Kurrianum . . 18, 29
Sphenophyllum 114
Spitzbergen, Coniferæ of, 24, 30, 32, 35, 36, 39, 42, 44, 53, 128
„ Basalt 77
„ Jurassic Cycads of . . 14
Spondylostrobus 20
Sporogonium 109
Spruce 16, 61
St. Etienne 115
St. Zacharie 4, 20, 24
Stachycarpus 48
Staffa 103
Steiermarkt 35
Steinhauera subglobosa . . . 55
Sternberg 57, 96
Sternbergia 115
Stewart 70
Stigmaria 113
Stonesfield 53
Strobus 11, 62
Studland 4
Styria 24, 42, 68
Submarine ridges, lines of plant-migration . 7
Suessonian 50
Sugar Pine 62
Sunda Isles 60
Superga 35
Swanston 90
Sweden 127, 128

PAGE

Swedenborgia 127
Swiss Tertiaries 42
Switzerland 16, 30, 92

Tar, coniferous 17
Tasmania . . . 29, 44, 47, 91
Tate and Holden 81
Taxeæ . . 43, 76, 124, 126, 128, 134
Taxineæ, *see* Taxeæ 76
Taxites 44, 101
„ acicularis 26
„ Campbelli 41
„ Langsdorfii 41
„ microphyllus 44
„ Olriki . . . 29, 90
„ Rosthorni 51
„ Tournalii 40
„ validus . . . 44, 90
Taxodieæ . . . 17, 29, 127, 134
Taxodites europæus 30
Taxodium . . . 12, 16, 29, 32, 127
„ angustifolium . . . 32
„ distichum . . . 30, 32, 42
„ „ miocænum . . 32
„ eocænum 31
„ europæum . . . 30, 92
„ heterophyllum . . . 31
„ „ (also Glyptostrobus) 87
„ var. imbricataria . . . 32
„ mexicanum . . 30, 32
„ Oeningense . . . 30
Taxus 102
„ adpressa 102
„ baccata . . . 16, 44
„ „ madeirensis . . . 90
„ Campbelli 101
„ cuspidata . . . 90, 102
„ Swanstoni 89
„ Wallichiana 44
Temperatures, Eocene and Miocene . . 5
Thallophytes 108
Thanet Beds 64, 65, 66
Théziers 5
Thuja 12, 19
„ borealis 19
„ europæa 19
„ gigantea . . . 16, 18, 86

	PAGE
Thuja occidentalis	86
„ orientalis	19, 86
„ sphæroidea	32
Thuja forests on the Baltic	79
Thuyites	11, 17, 128
„ Ehrenswærdi	19, 84
„ Meriani	19, 84
„ Parryanus	84
„ Pfaffii	19
Thuyopsis	17
„ dolobrata	19
Tæda	128
Tongrian	4, 19, 24
Totara	98
Torrellia	44
Torreya	43, 44, 50, 98
„ nucifera	44
„ „ brevifolia	44
„ taxifolia	44
Tree enveloped in lava	106
Treshnish Isles	103
Trias, Gymnosperms of the	11, 125, 127
Trichopitys	45, 114, 125, 126
Trigonocarpus	10, 45, 115
Tsuga	12, 60, 70, 73, 128, 136
„ Heerii	61, 74
„ jessoensis	74
„ Pattoniana	75
„ Sieboldi	73
Turin	35, 39
Turonian	132
Tyrone	77
Uig, Isle of Skye, Coniferæ from	42
Ulva	108
Ullmannia	11, 17, 29, 125, 126
Unger	49, 68, 72, 74, 92, 101
Upper Greensand	132
Valentine, Tufs de la	5
Val d'Arno	30
Value of Coniferous woods	18
Van Diemen's Land	22, 43
Vaucheria	108
Veitch's "Manual of the Coniferæ,"	15, 28, 33, 37, 57, 63, 66, 75, 83, 86 98, 102
Venezuela	98
Versailles	47
Virginia	66
Voltzia	11, 53, 125, 127
Walchia	11, 53, 125, 126
Wallace	48
Wealden Flora	11, 29, 60, 61, 126, 127, 132
Weber	42, 101
Wellingtonia gigantea (also Sequoia)	91
Welwitschia	141, 142
Wetherell	64
Wetterau	44, 49, 61
Widdringtonia	19, 91, 128
„ cupressoides	86
„ helvetica	84
„ juniperoides	86
Widdringtonites	11, 17, 128
Williamson, W. C.	107, 112, 113, 114, 115, 124
Williamsonia	132
Witham on Carboniferous Plants	10
Wood, value of Coniferous	18
„ dimensions of	18
Woodwardian Museum	67
Woolwich Beds	25
Whymper	2, 38, 39, 70, 82, 84
Yew, *see* also Taxus	16, 24, 101, 124
Yorkshire, fossil Coniferæ of	11, 53
Yosemite Valley	25
Zamia macrophylla	63
„ ovata	65
Zamieæ	120
Zamiostrobus	63, 65
„ Henslowi	63
„ Saportanus	120
Zamites	63, 65
„ epibius	120

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PLATE I.

From the Middle Bagshot, Bournemouth.

Cupressus taxiformis, Unger, sp.

Figs. 1, 2. Exceptionally long branchlets, uniting the two kinds of foliage.

3, 4. Specimens illustrating the usual mode of occurrence of *Cupressus taxiformis* in the Bournemouth Beds.

5, 6, 7. Examples of the distichous foliage.

5 *a*. An enlarged portion.

8. Exceptionally slender distichous foliage.

9, 10, 11. Imbricated foliage.

3 *a*, 11 *a*, 13. The same magnified.

12. Male catkins.

12 *a*. The same enlarged.

(From the "Upper Coastguard Beds" at Bournemouth. In the Author's Collection.)

West Newman & Co imp

EOCENE CONIFERÆ.

PLATE II.

From the Middle Bagshot, Bournemouth.

Podocarpus incerta, sp. nov.

Figs. 1—5.

1 *a*. Portion enlarged.

(From the Gleichenia Beds at Bournemouth. Fig. 5 is from the Woodwardian Museum; the rest are in the Author's Collection).

Podocarpus eocænica, Unger.

6, 7, 11. Leaflets.

9, 10. Longer leaflets, probably of the same species.

8, 12. Smaller specimens ascribed doubtfully to *Podocarpus eocænica*.

(From the "Upper Coastguard Beds" at Bournemouth. In the Author's Collection.)

16. Leaf suggesting *Agathis*.

21. Scale of a cone? possibly belonging to Agathis.

(From the "Gleichenia Bed" at Bournemouth. In the British Museum.)

From the Barton Series, Hordwell.

13, 14. Leaflets, possibly of *Podocarpus*. (In the British Museum.)

From the Lower Bagshot, Alum Bay.

15. Leaf of *Podocarpus eocænica*, or an allied form. (In the Author's Collection.)

From the Woolwich Beds, Bromley.

Libocedrus adpressa, sp. nov.

17—20. Branchlets. (In the Author's Collection.)

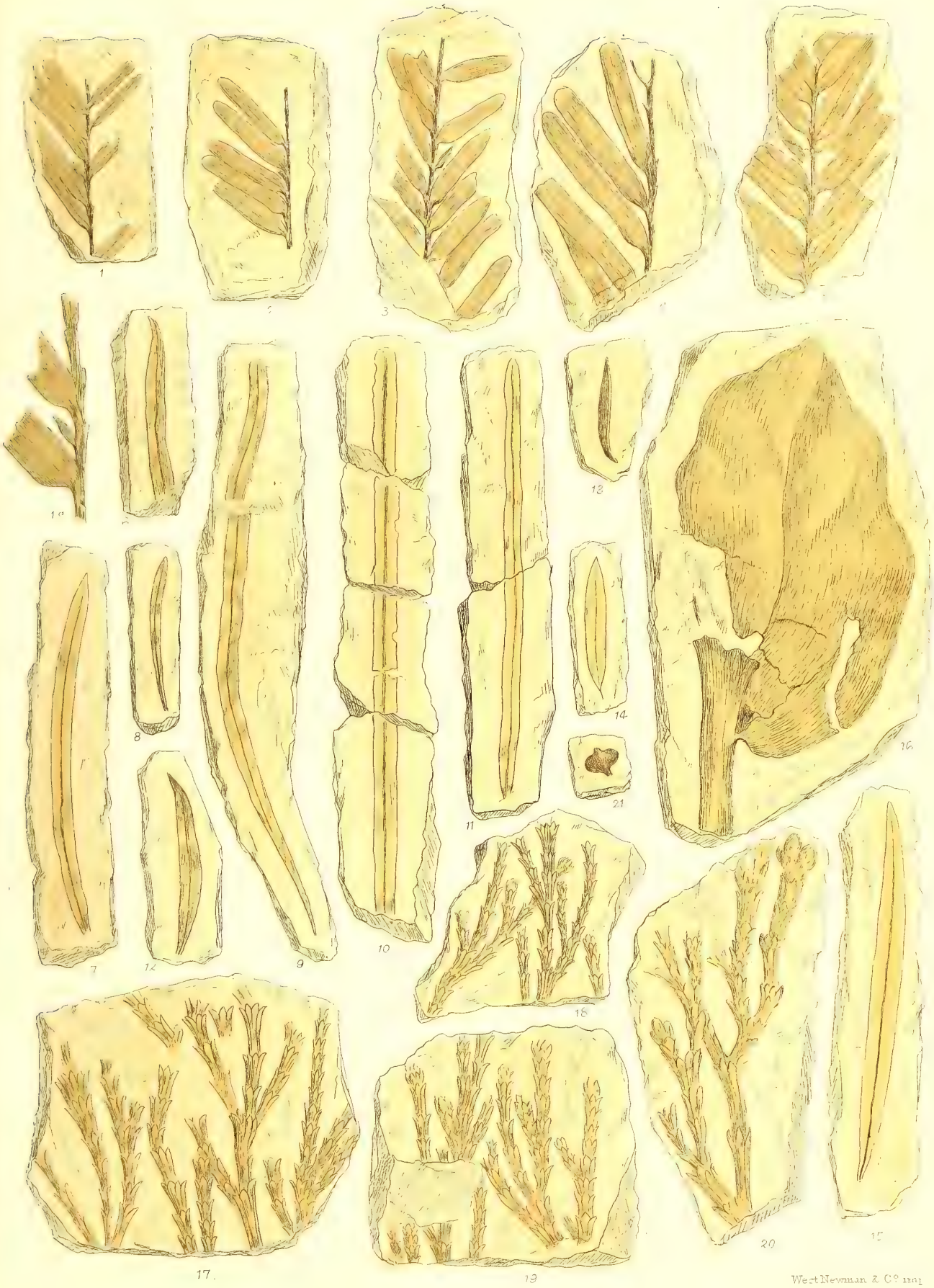

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PLATE III.

From the Middle Bagshot, Bournemouth.

Taxodium europœum, Brongt.

Figs. 1—9. Specimens from the "Willow Beds."
2 *a*, 6 *a*, 6 *b*, 9 *a*—9 *c*. Parts of the same, enlarged.

(In the Author's Collection.)

PLATE IV.

From the Middle Bagshot, Bournemouth.

Taxodium europœum, Brongt.

Figs. 1—8. Specimens from the "Laurel Beds."

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6
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PLATE V.

Middle Bagshot, Bournemouth.

Sequoia Tournalii, Brong., sp.

Figs. 1, 3. Specimens exhibiting imbricated and distichous foliage on the same branch.
2, 4, 5, 9, 12. Examples of the distichous foliage.
6—8, 10, 11. Examples of the imbricated foliage.
10 *a*. A part of the same enlarged.

(All the specimens except figs. 9 and 12 are from the "Upper Coastguard Beds;" fig. 12 is from the "Myrica Bed," and fig. 9 from near Poole. In the Author's Collection.)

Cupressus taxiformis, Unger, sp.

13. Example of distichous foliage.
14. Scales of a cone.

(From a rolled block, embedded below the Coastguard Beds at Bournemouth. In the Author's Collection.)

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PLATE VI.

Upper Eocene Hempstead.

Sequoia Couttsiæ, Heer.

Figs. 1—6, 8. Cones and foliage.

9. Specimen of foliage from an ironstone concretion, Gurnet Bay. (In the British Museum.)

Middle Eocene, Bovey Tracey.

7. Foliage.

10—12. Cones.

13. Seed.

14—17. Branchlets. (In the Jermyn Street Museum.)

18. Foliage of *S. Whymperi*, sp. nov. Natural size, Greenland. (In the British Museum.)

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PLATE VII.

MIDDLE BAGSHOT, BOURNEMOUTH.

Taxodium eocænum, sp. nov.

Figs. 1, 2. Branches, one half natural size.
2 *a*—2 *d*. Portions of foliage enlarged.
3. Branch with distichous foliage.
4. Branchlet, natural size.
5, 7. Male flowers.
6. Female flowers.
8. Seed of *Cupressus taxiformis*.

(From the "Upper Coastguard Beds," Bournemouth. In the Author's Collection.)

PLATE VIII.

LOWER BAGSHOT, ALUM BAY.

Podocarpus elegans, De-la-Harpe, sp.

Figs. 1—4, 6. Examples of an intermediate type of foliage.
5, 7, 8, 10, 12, 14. Examples of distichous foliage.
9, 13. Examples of imbricated foliage.
11. Branch showing imbricated and distichous foliage united.
15. Male flowers.
16. Fruit.
10 *a*. Distichous foliage, enlarged.

(1—5, 8, 11—13, 15, are in the British Museum, and the remainder in the Author's Collection.)

West Newman & C° imp

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PLATE IX.

FROM THE LONDON CLAY, ISLE OF SHEPPEY.

Callitris Ettingshausenii, sp. nov.

Figs. 1. Side view of an 8-valved cone.
2, 3. Basal views of the same.
4. View of the apex.
5. Apex of 6-valved cone.
6. Side view of the same.

(In the Author's Collection.)

Callitris curta, Bow., sp.

7, 8. Two views of a 3-valved cone.
9—11. Three views of a 4-valved cone. (The original specimen described by Bowerbank as *Cupressinites thujoides*.)
12. Section of a 4-valved cone. (The original specimen described as *C. crassus*, Bow.)
13—21. 5-valved cones. (Figs. 15—17, the original specimen, described as *C. subangulatus*, Bow.)
(7, 8, 13, 14, 18—21, are in the Author's Collection; the remainder in the British Museum.)

Podocarpus argillæ-londinensis, sp. nov.

35, 36. Side view and apex of the fruit. (In the Author's Collection.)

Ginkgo (*?*) *eocænica*, Ett. and Gard.

31, 32. Apex and side view of a medium sized fruit.
33, 34. End and side view of the largest fruit.

(In the British Museum.)

MIDDLE BAGSHOT, BOURNEMOUTH.

Cupressus taxiformis, Ung., sp.

22. Basal view of a cone.
24. Apex of same, showing the two apical scales soldered together.
23, 25. Side views of the same cone.
30. Foliage.
26. Smaller cone, probably of the same.
27. Cone resembling so-called cones of *Sequoia Couttsiæ*.

(The above are from the "Marine Beds.")

28, 29. Sections of a cone of *Cupressus taxiformis*, from the fresh-water "Black Bed" of the "Coastguard Beds."

(In the Author's Collection.)

G.M.Herschell, lith.

EOCENE CONIFERÆ.

PLATE X.

Sequoia ? Langsdorfii, Brongn., sp.

Fig. 1. Branch, originally figured as *Taxites Campbellii*, 'Quart. Journ. Geol. Soc.,' vol. vii, pl. ii, fig. 1 *a*, *b*.

1 *a*. Portion enlarged to show mode of attachment of leaflets to branch.

(From the Basaltic Formation, Isle of Mull. In the Jermyn Street Museum.)

Cryptomeria Sternbergii, Goeppert, sp.

2. A specimen from the Isle of Canna. (In the Edinburgh Museum.)

3. Branchlet from Mull. (In the Glasgow University Museum.)

3 *a*. Part magnified.

Taxus Swanstoni, sp. nov.

4. Branchlet.

5. Another example.

4 *a*, 4 *b*. Portions enlarged with abortive leaflets.

(From the Basaltic Formation, Ballypalady. In the Author's Collection.)

Athrotaxis Couttsiæ, Heer, sp.

6, 8. Foliage.

7. Foliage and cone.

7 *a*. The same enlarged.

9. A cone.

(From the Upper Eocene, Hordwell. In the Author's Collection.)

Cryptomeria Sternbergii, Goeppert, sp.

10—13. Cones showing exterior forms of some of the scales.

(From the Basaltic Formation, Ballypalady.)

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PLATE XI.

From the Middle Bagshot, Bournemouth.

Araucaria Goepperti, Sternb., sp.

Fig. 1. Impression of foliage in sandy clay, showing variations due to the seasons.

(Author's Collection.)

From the London Clay, Sheppey.

Athrotaxis subulata, sp. nov.

2—14. Fragments of foliage showing disposition and different types of leaflets.
6. Mature cone attached to branch.

(Figs. 6—10 in the Author's Collection, the remainder in the British Museum.)

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PLATE XII.

MIDDLE BAGSHOT, BOURNEMOUTH.

Araucaria Goepperti, Sternb.

Fig. 1. Part of a perfect branchlet ; *a*, swollen bud ; *b*, ordinary bud.
2. A smaller specimen of foliage.

(From the Author's Collection, now in the British Museum.)

Fig 2.

Fig. 1

E.C.Woodward. del. et lith.

EOCENE CONIFERÆ.

West, Newman & Co imp

PLATE XIII.

Pinus Dixoni, Bowerbank, sp.

Fig. 1. Cone.
2. Reverse of Fig. 1.
8. Another specimen.

(From the Middle Bagshot, Bracklesham. Woodwardian Museum, Cambridge.)

4. Somewhat abraded cone, presumed to be of the same species as above.

(From the Bembridge Marls, Gurnet Bay. In the possession of Mr. J. A'Court Smith.)

5. Much abraded cone.

(From the Middle Bagshot, Highcliff. Author's Collection.)

Pinus Prestwichii, sp. nov.

3. Impression of the cone.

(From the Thanet Beds, Herne Bay. In Professor Prestwich's Collection.)

Pinus Bowerbankii, Carr., sp.

6. Imperfect cone.

(From the Middle Bagshot, Highcliff.)

9. Imperfect cone.

(From the Middle Bagshot, Bracklesham. Author's Collection.)

Araucaria Goepperti ?, Sternb., sp.

7. Branchlet, with long and slender leaflets.

(From the Bembridge Marls, Hempstead. Author's Collection.)

10. Branchlet. (From the Middle Bagshot, Highcliff. British Museum.)

G.M. Woodward, del. et lith.

West, Newman & Co. imp.

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PLATE XIV.

From the Thanet Beds, East Kent.

Pinus macrocephalus, Lindley and Hutton, sp.

Figs. 1, 2. Section of cone, parallel to the axis, showing internal structure.
6. Fragment of a cone.
7. Entire cone, showing internal and external structure.

(British Museum.)

Pinus ovata, Lindley and Hutton, sp.

4, 5. Transverse sections of cone.

(British Museum.)

From the London Clay, Sheppey.

Pinus Bowerbankii, Carr., sp.

3. Much abraded specimen, showing seeds adhering to the axis.
8. A similar specimen.

(British Museum.)

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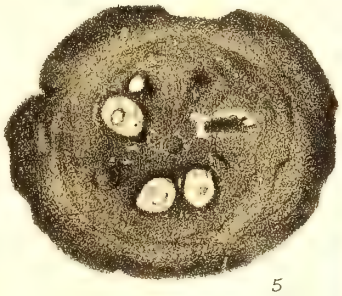

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PLATE XV.

From the Basaltic Formation, Ballypalady.

Pinus Plutonis, Baily.

Fig. 1. Branchlet showing attachment of needles. Their entire length is not shown.
3. Branch with three cones attached, showing erect position of growth.
4 Branch with leaf scars.
6. Pine cone.
7. Fragment of bark, with older leaf scars.
8. Perfect cone.

Pinus Bailyi, sp. nov.

2. Branchlet with needles.
5. Perfect cone.
9. Branchlet.

(Figs. 1, 3, 7, in the Belfast Museum, the rest in the Author's Collection.)

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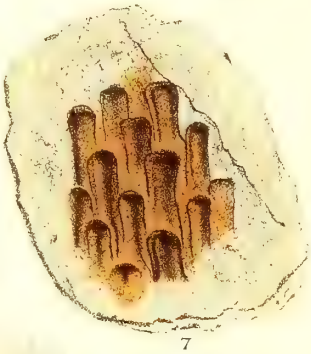

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8

9

C. Forrieau, lith.

EOCENE CONIFERÆ.

West, Newman & Co. imp.

PLATE XVI.

From the Basaltic Formation, Ballypalady.

Tsuga Heerii, sp. nov.

Fig. 1. Impression of cone.
2. Smaller cone on stem.
3. Smaller, possibly less matured cone.
4. Another specimen with seeds. The small cone on the same block is *Cupressus Pritchardi*.
10—13. Acicular leaves, probably of same species.
14, 15. Separate scales of a leathery cone.
16. Seed, probably of *Tsuga* or *Abies*.

(Author's Collection, except figs. 3 and 11, which are in the Belfast Museum.)

Pinus Plutonis?, Baily.

5. Impression of part of axis of cone with pair of seeds towards apex.
6. Another specimen, with seeds and a pine twig.
7. More perfect specimen, showing arrangement of seeds in pairs.
17. Another specimen.

(Author's Collection.)

Cupressus Pritchardi, Goepp.

8. The upper specimen exhibits the face of the scale, the lower one the under side of scale.
9. Transverse section of cone, showing striated under surface of scale.

(Author's Collection.)

E. C. Knight lith.

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PLATE XVII.

From the Basaltic Formation, Ballypalady.

Pinus Plutonis, Baily.

Fig. 1. Scale of cone.
2, 3, 5. Winged seeds.
6. Double needle, perfect except the base.
7. Fragment of old bark.
8. Double needle and winged seed.
9. Needles.

(Author's Collection.)

Pinus Bailyi, sp. nov.

4. Double needle.

(Author's Collection.)

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E.C.Knight del et lith.

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West, Newman & Co imp

PLATE XVIII.

Basaltic Formation, Ballypalady.

Pinus Plutonis, Baily.

Fig. 1. Foliage of *Pinus Plutonis*, Baily, with cluster of three cones of *Cupressus Pritchardi*, Goepp., in transverse section, and single cone showing under side of scales.

2. Foliage attached to branch, reduced by one fourth.
3. Closed cone with footstalk.
4. Male catkin.
5. Right-hand impression, branch with leaf scars; left-hand do., part of closed cone; centre do., partly opened cone with seeds.

(Author's Collection.)

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— 1/4

2.

E.C. Knight del. et lith.

West, Newman & C° imp.

EOCENE CONIFERÆ.

PLATE XIX.

From the Basaltic Formation, Ballypalady.

Cupressus Pritchardi, Goepp.

Fig. 1. Branch.

1 *a*, 1 *b*, 1 *c*. Portions enlarged, showing different types of foliage.

2. Another branch.

3. Fragment of foliage.

4. Branchlet.

4 *a*, 4 *b*. Portions enlarged.

5. Two cones attached.

6. Section through cone.

7—9. Cones showing forms of scale-heads.

10—13. Cones gaping or squeezed open by pressure, showing upper and under surfaces of scales.

(Author's Collection.)

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PLATE XX.

From the Basaltic Formation, Ballypalady.

Cryptomeria Sternbergii, Goepp., sp.

Fig. 1. Foliage.

1 *a*, 1 *b*, 1 *c*. Portions enlarged.

2. Specimen with longer and straighter leaflets.

3. Foliage and cone.

3 *a*, 3 *b*. Portions of foliage enlarged.

4. Foliage and part of cone enlarged.

5. Foliage. The thickening seen in two places is due to lateral shoots being pressed against the main stem.

6. Foliage and fimbriated scale of cone.

6 *a*. Portion enlarged.

7—13. More or less broken cones.

(Author's Collection.)

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PLATE XXI.

From the Basaltic Formation, Glenarm.

Cryptomeria Sternbergii, Goepp., sp.

Fig. 1. Foliage with cones attached.
2. Transverse section of a cone.
3. Two cones.
4, 5. Longitudinal sections of two cones.

(Collected by the Author. In the British Museum.)

Fig 1.

PLATE XXI.

F. C. Woodward del. et lith.

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PLATE XXII.

From the Bembridge Marls, Gurnet Bay.

Doliostrobus Sternbergii, Goepp., sp.

Figs. 1—12, except fig. 10. Various examples of the foliage. The disc on fig. 5 is possibly the scale of a cone of the same species.

10. *Athrotaxis Couttsiæ*, Heer, sp.

(In the Collection of Mr. E. A'Court Smith.)

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PLATE XXIII.

From the Bembridge Marls, Gurnet Bay.

Doliostrobus Sternbergii, Goepp., sp.

Branch and foliage.

(In the Collection of Mr. E. A'Court Smith.)

E.C.Woodward lith

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PLATE XXIV.

From the Reading Beds, Reading.

Taxodium europæum, Brongt.

(Collected by the Author. In the British Museum.)

PLATE XXV.

From the Basaltic Formation, Ardtun Head, Mull.

Ginkgo adiantoides, Unger.

Figs. 1, 3. Under side of leaves.
2, 4, 5. Upper side of leaves.

(Collected by the Author. In the British Museum.)

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PLATE XXVI.

From the Basaltic Formation, Ardtun Head, Mull.

Podocarpus Campbelli, sp. nov.

Fig. 1. Detached leaflets and a terminal shoot.
2. A branchlet with foliage.
3. A young branchlet.

(Collected by the Author. In the British Museum.)

S.G.sculpt.

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PLATE XXVII.

Figs. 1—3 from the Basaltic Formation, Ardtun Head, Mull.
4 from the Bembridge Marls, Gurnet Bay.

Taxus Campbelli, Forbes, sp.

Fig. 1. Foliage ; fig. 1, *a* same enlarged. Collected by the Author.
2. Foliage in the Collection at Inveraray.
3. Foliage of Taxodium (?). Author's collecting.
4. *Athrotaxis Couttsiæ*, Heer, sp. In Mr. A'Court Smith's Collection.
4*a*. Part of same enlarged.

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